

## Deaths: Final Data for 2005

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### Abstract

*Objectives*—This report presents final 2005 data on U.S. deaths; death rates; life expectancy; infant and maternal mortality; and trends by selected characteristics such as age, sex, Hispanic origin, race, marital status, educational attainment, injury at work, state of residence, and cause of death.

*Methods*—This report presents descriptive tabulations of information reported on death certificates, which are completed by funeral directors, attending physicians, medical examiners, and coroners. The original records are filed in the state registration offices. Statistical information is compiled into a national database through the Vital Statistics Cooperative Program of the Centers for Disease Control and Prevention's, National Center for Health Statistics (NCHS). Causes of death are processed in accordance with the *International Classification of Diseases, Tenth Revision* (ICD-10).

*Results*—In 2005, a total of 2,448,017 deaths were reported in the United States. The age-adjusted death rate was 798.8 deaths per 100,000 standard population, representing a decrease of 0.2 percent from the 2004 rate and a record low historical figure. Life expectancy at birth remained the same as in 2004- 77.8 years. Age-specific death rates decreased for the age group 65-74 years but increased for the age groups 15-24 years, 25-34

years, and 45-54 years. The 15 leading causes of death in 2005 remained the same as in 2004. Heart disease and cancer continued to be the leading and second leading causes of death, together accounting for almost half of all deaths. The infant mortality rate in 2005 was 6.87 per 1,000 live births.

*Conclusions*—Generally, mortality patterns in 2005, such as the age-adjusted death rate declining to a record historical low, were consistent with long-term trends. Life expectancy in 2005 remained the same as in 2004.

**Keywords:** deaths mortality cause of death life expectancy vital statistics ICD–10

## **Highlights**

### **Mortality experience in 2005**

- + In 2005, a total of 2,448,017 resident deaths were registered in the United States.
- + The age-adjusted death rate, which takes the aging of the population into account, was 798.8 deaths per 100,000 U.S. standard population.
- + Life expectancy at birth was 77.8 years.
- + The 15 leading causes of death in 2005 were:
  - Diseases of heart (heart disease)
  - Malignant neoplasms (cancer)
  - Cerebrovascular diseases (stroke)
  - Chronic lower respiratory diseases
  - Accidents (unintentional injuries)
  - Diabetes mellitus (diabetes)
  - Alzheimer's disease
  - Influenza and pneumonia
  - Nephritis, nephrotic syndrome and nephrosis (kidney disease)

Septicemia

Intentional self-harm (suicide)

Chronic liver disease and cirrhosis

Essential (primary) hypertension and hypertensive renal disease (hypertension)

Parkinson's disease

Assault (homicide)

+ In 2005, the infant mortality rate was 6.87 infant deaths per 1,000 live births.

+ The 10 leading causes of infant death were:

Congenital malformations, deformations, and chromosomal abnormalities (congenital malformations)

Disorders relating to short gestation and low birth weight, not elsewhere classified (low birthweight)

Sudden infant death syndrome (SIDS)

Newborn affected by maternal complications of pregnancy (maternal complications)

Newborn affected by complications of placenta, cord, and membranes (cord and placental complications)

Accidents (unintentional injuries)

Respiratory distress of newborn

Bacterial sepsis of newborn

Neonatal hemorrhage

Necrotizing enterocolitis of newborn

## **Trends**

+ The age-adjusted death rate in 2005 was a record low.

+ Life expectancy was 77.8 years, the same as in 2004. Life expectancies remained unchanged for the total population and for the white population, while life expectancy for the black population increased by 0.1 year.

Life expectancy for white males, white females and black males remained at 2004 levels while life

expectancy for black females increased by 0.2 year.

- + Among the 15 leading causes of death, age-adjusted death rates decreased significantly from 2004 to 2005 for the top three leading causes, heart disease, cancer, and stroke, as long-term decreasing trends for these causes continued. Significant increases occurred for Chronic lower respiratory diseases, unintentional injuries, Alzheimer's disease, Influenza and pneumonia, hypertension, Parkinson's disease and homicide.
- + Differences in mortality between men and women continued to narrow as the age-adjusted death rate for men was 40.4 percent greater than that for women (down from 40.7 percent greater in 2004) while the difference between male and female life expectancy remained at 5.2 years in 2005.
- + Differences in mortality between the black and white populations persisted. The age-adjusted death rate was 1.3 times greater, the infant mortality rate 2.4 times greater, and maternal mortality rate 3.3 times greater for the black population than that for the white population. Life expectancy for the white population exceeded that for the black population by 5.1 years.
- + The postneonatal mortality rate increased 3.1 percent between 2004 and 2005 and contributed to the observed but not statistically significant increase in the infant mortality rate.

## Introduction

This report presents detailed 2005 data on deaths and death rates according to a number of social, demographic, and medical characteristics. These data provide information on mortality patterns among residents of the United States by such variables as age, sex, Hispanic origin, race, marital status, educational attainment, injury at work, state of residence, and cause of death. Information on these mortality patterns is important for understanding changes in the health and well-being of the U.S. population (1). Preliminary data for 2005 were presented in the Health E-Stats “Deaths: Preliminary Data for 2005” using a 99 percent (demographic file) sample of U.S. deaths weighted to independent control totals (2). Findings of the preliminary data for 2005 were also summarized in *QuickStats* in October 2007 (3,4). The findings in this report, based on the final mortality file, are generally consistent with those based on preliminary data; the final mortality file incorporates some modifications to the preliminary file as described in the “[Technical Notes](#).” Separate companion reports will present additional details on leading causes of death, injury-related deaths, and life expectancy in the United States (5-7).

Mortality data in this report can be used to monitor and evaluate the health status of the Nation in terms of current mortality levels and long-term mortality trends, as well as to identify segments of the U.S. population at greater risk of death from specific diseases and injuries. Differences in death rates among various demographic subpopulations, including race and ethnic groups, may reflect subpopulation differences in factors such as socioeconomic status, access to medical care, and the prevalence of specific risk factors of a particular subpopulation.

## Methods

Data in this report are based on information from all resident death certificates filed in the 50 states and the District of Columbia. It is believed that more than 99 percent of deaths occurring in this country are registered (8). Tables showing data by state also provide information for Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands (Northern Marianas). Cause-of-death statistics

presented in this report are classified in accordance with the *International Classification of Diseases, Tenth Revision* (ICD–10) (9). (A discussion of the cause-of-death classification is provided in the “[Technical Notes](#).”)

Mortality data on specific demographic and medical characteristics except educational attainment cover all 50 states and the District of Columbia. Educational attainment data are provided for 31 states. Details on reporting areas for educational attainment are provided in the “[Technical Notes](#).”

Measures of mortality in this report include the number of deaths; crude, age-specific, and age-adjusted death rates; infant, neonatal, postneonatal, and maternal mortality rates; life expectancy; and rate ratios. Changes in death rates from 2004 to 2005 and differences in death rates across demographic groups in 2005 are tested for statistical significance. Unless otherwise specified, reported differences are statistically significant. Additional information on these statistical methods, random variation and relative standard error, the computation of derived statistics and rates, population denominators, and the definition of terms is presented in the “[Technical Notes](#).”

The populations used to calculate death rates for 2000–05, and the intercensal period 1991–99 shown in this report were produced under a collaborative arrangement with the U.S. Census Bureau and are consistent with the 2000 census. Reflecting the new guidelines issued in 1997 by the Office of Management and Budget (OMB), the 2000 census included an option for individuals to report more than one race as appropriate for themselves and household members (10); see “[Technical Notes](#).” The 1997 OMB guidelines also provided for the reporting of Asian persons separately from Native Hawaiians or other Pacific Islanders. Under the prior OMB standards (issued in 1977), data for Asian or Pacific Islander persons were collected as a single group (11). Most death certificates currently collect only one race for the decedent in the same categories as specified in the 1977 OMB guidelines (that is, death certificate data do not report Asians separately from Native Hawaiians or other Pacific Islanders). Death certificate data by race (the source of the numerators for death rates) are thus currently incompatible with the population data collected in the 2000 census and postcensal estimates (the denominators for the rates). To produce death rates by race for 2000–05, and revised intercensal rates for the 1991–99 period, it was necessary to “bridge” the reported population data for multiple-race persons back to single-race categories. In addition, the 2000 census counts were modified to be consistent with the 1977 OMB

race categories, that is, to report the data for Asian persons and Native Hawaiians or other Pacific Islanders as a combined category, Asian or Pacific Islanders, and to reflect age as of the census reference date (12). The procedures used to produce the “bridged” populations are described in separate publications (13,14). It is anticipated that “bridged” population data will be used over the next few years for computing population-based rates by race. Beginning with deaths occurring in 2003, some states allowed for multiple-race reporting on the death certificate. Multiple-race data for these states are “bridged” back to single-race categories; see “[Technical Notes](#).” Once all states are collecting data on race according to the 1997 OMB guidelines, it is expected that use of the “bridged” race algorithm will be discontinued.

Readers should keep in mind that the population data used to compile death rates by race shown in this report are based on special estimation procedures. They are not true counts. This is the case even for the 2000 populations. The estimation procedures used to develop these populations contain some error. Smaller population groups are affected much more than larger populations (13). Over the next several years, additional information will be incorporated in the estimation procedures, possibly resulting in further revisions of the population estimates; see “[Technical Notes](#).”

Data presented in this report and other mortality tabulations are available on the NCHS Web site at: <http://www.cdc.gov/nchs/deaths.htm>. Availability of mortality microdata is described in the “[Technical Notes](#)” of this report.

## Results and Discussion

### Deaths and death rates

In 2005, a total of 2,448,017 resident deaths were registered in the United States, 50,402 more than in 2004. The crude death rate for 2005, 825.9 deaths per 100,000 population, was 1.2 percent more than the 2004 rate (816.5) ([Tables 1](#) and [A](#)).

The age-adjusted death rate in 2005 was 798.8 deaths per 100,000 U.S. standard population, a record low value that was 0.2 percent lower than the 2004 rate of 800.8 ([Tables 1](#) and [A](#)). Age-adjusted death rates are constructs that show what the level of mortality would be if no changes occurred in the age composition of the population from year to year. (For a discussion of age-adjusted death rates, see “[Technical Notes](#).”) Thus, the age-adjusted death rates are better indicators than unadjusted (crude) death rates for examining changes in the risk of death over a period of time when the age distribution of the population is changing. Also, age-adjusted death rates are better indicators of relative risk when comparing mortality across geographic areas or between sex or race subgroups of the population that have different age compositions; see “[Technical Notes](#).” Since 1980, the age-adjusted death rate has decreased every year except 1983, 1985, 1988, 1993, and 1999. These were years when influenza outbreaks contributed to increased mortality in the United States ([15-18](#)). Between 1980 and 2005, the age-adjusted death rate declined 23.1 percent ([Figure 1](#) and [Table 1](#)).

*Race*—In 2005, age-adjusted death rates for the major race groups ([Table 1](#)) were:

- + White population, 785.3 deaths per 100,000 U.S. standard population
- + Black population, 1,016.5
- + American Indian or Alaska Native (AIAN) population, 663.4
- + Asian or Pacific Islander (API) population, 440.2

Rates for the AIAN and API populations should be interpreted with caution because of reporting problems with respect to correct identification of race on both the death certificate and in population censuses and surveys. The net effect of the reporting problems is for the AIAN rate to be approximately 30 percent



understated and the API rate to be approximately 7 percent understated (19).

In 2005, the age-adjusted death rate for the black population was 1.3 times that for the white population (Table C); that is, the average risk of death for the black population was about 30 percent higher than for the white population. The ratio shown to one decimal place has remained constant since 1997 (Table 1). Between 1960 and 1982, rates for the black and white populations declined by similar percentages (22.6 and 26.5 percent, respectively). For the period ranging from 1982 to 1988, rates diverged (20), increasing 5.2 percent for the black population and decreasing 1.7 per cent for the white population. The disparity in age-adjusted death rates between the black and white populations reached its widest point in 1989. Since then, rates for the black and white populations have tended toward convergence, declining by 10.6 percent for the black population and by 7.0 percent for the white population between 1989 and 1997 and by 10.8 percent for the black population and by 8.2 percent for the white population since 1997.

Between 2004 and 2005, decreases in age-adjusted death rates were observed for white males and for both black males and females. In order of relative magnitude of decrease, the reductions from 2004 were 1.3 percent for black males, 1.1 percent for black females, and 0.4 percent for white males (Tables A and 1).

Age-adjusted death rates have generally declined between 1980 and 2005 for white males and females. However, increases were observed for both white males and white females in 1983, 1985, 1988, and 1993. In addition, the age-adjusted death rate for white females increased in 1995 and 1999. For black males, age-adjusted death rates tended to decrease except for a period of increase between 1983 and 1988; rates for black females decreased between 1980 and 2005, although with considerable variability in direction of change from year to year (Table 1).

*Hispanic origin*—Problems of race and Hispanic-origin classification affect Hispanic death rates and the comparison of rates for the Hispanic and the non-Hispanic population; see “Technical Notes.” Mortality for Hispanics is somewhat understated because of net under-reporting of Hispanic origin on the death certificate. Hispanic origin on the death certificate is underreported by an estimated 5 percent (19); see “Technical Notes.” The age-adjusted death rate for the Hispanic population in 2005 did not change significantly from the rate in

2004 ([Tables B and 2](#)). The age-adjusted death rate for the total non-Hispanic population decreased by 0.2 percent relative to 2004. The rate for the non-Hispanic white population also decreased but not significantly. The age-adjusted death rate for the non-Hispanic black population declined 1 percent from the previous year.

Among Hispanic males, the age-adjusted death rate increased by 1.4 percent between 2004 and 2005. The age-adjusted death rate for non-Hispanic white males and non-Hispanic black males declined 0.4 and 1.3 percent, respectively. Rates for Hispanic females were not significantly different. The rate for non-Hispanic black females declined 1 percent while the non-Hispanic white female age-adjusted death rate remained statistically unchanged ([Tables B and 2](#)).

In 2005, the age-adjusted death rate ([Table 2](#)) was 27.3 percent lower for the Hispanic population than for the non-Hispanic population. Similarly, the age-adjusted death rate for the Hispanic population was 25.8 percent lower than the rate for the non-Hispanic white population and considerably lower (42.9 percent) than the rate for the non-Hispanic black population. The large differences in mortality between the Hispanic and non-Hispanic populations are partly a function of the Hispanic population's lower age-specific death rates particularly at older ages ([Table 4](#)). Part of the difference is also attributable to underreporting of Hispanic origin on the death certificate. In addition, there are various hypotheses that have been proposed to explain Hispanics' favorable mortality outcomes. The most prevalent hypotheses include the healthy migrant effect, which argues that Hispanic immigrants are selected for their good health and robustness; and, the so-called "salmon bias" effect, which posits that U.S. residents of Hispanic origin may return to their country of origin to die or when ill ([21, 22](#)).

Within the Hispanic population, the age-adjusted death rate for males was 1.5 times that for females ([Table 2](#)). The corresponding ratios within the non-Hispanic white population and the non-Hispanic black population were 1.4 and 1.5, respectively.

The age-adjusted death rates in 2005 for selected Hispanic sub-groups ([Table 5](#)), in order of relative magnitude, were:

- + Puerto Rican population, 822.5 deaths per 100,000 U.S. standard population
- + Mexican population, 582.2
- + Cuban population, 531.3
- + Central and South American, 416.3

The differences between the age-adjusted rate of the Puerto Rican and other Hispanic subgroup populations listed above and between the Mexican and Central and South American populations are statistically significant. The difference between the age-adjusted rates of the Mexican or Central and South American and Cuban populations are not statistically significant; however, this is a function of the large statistical variation in age-specific death rates for some of the Hispanic subgroups, reflecting their relatively small population sizes.

### **Death rates by age and sex**

The only statistically significant drop in age-specific death rates between 2004 and 2005 occurred among those aged 65-74 years (1.3 percent) ([Table A](#) and [Figure 2](#)). An increase in age-specific death rates was observed for 15-24 years, 25-34 years, and 45-54 years between 2004 and 2005.

The death rates for males declined between 2004 and 2005 for age groups 65-74 years, 75-84 years, and 85 years and over. There were increases in age-specific death rates among males in age groups 15-24 years and 25-34 years in 2005. The largest statistically significant decrease for males occurred among those aged 65-74 years (1.2 percent). The largest statistically significant increase for males occurred among those 25-34 years (2.8 percent). For females, death rates declined for the age groups 1-4 years, 55-64 years, and 65-74 years. The largest drop in the age-specific rates for females occurred among those aged 1-4 years (8.1 percent). The only statistically significant increase for females occurred for those aged 45-54 years (1.8 percent).

*Race*—Age-specific death rates declined for white males for the following age groups in 2005: 65–74

years, 75–84 years and 85 years and over. The largest decrease was for age group 65-74 years (1.2 percent). Rates for white males increased for age groups 25-34 years (3.0 percent) and 45-54 years (1.1 percent). Rates for the black male population in 2005 decreased for age groups 65-74 years and 85 years and over. The largest statistically significant decrease for black males was noted for the age group 85 years and over (4.4 percent). The only statistically significant increase for black males was for the age group 15-24 years (4.7 percent). For white females, the death rate decreased in 2005 for those aged 55-64 years and 65-74 years. The largest decrease was observed for age group 65-74 years (1.3 percent). The only statistically significant increase for white females was for the age group 45-54 years (2.0 percent). Age-specific rates for black females decreased for age groups 55-64 years and 65-74 years. The largest decrease was observed for age group 55-64 years (2.2 percent). For black females, there were no significant increases in age-specific death rates between 2004 and 2005.

*Hispanic origin*—For the Hispanic origin population, between 2004 and 2005 ([Table B](#)), the age-specific death rate increased for age groups under 1 year (4.6 percent), 15-24 years (6.1 percent), and 25-34 years (4.7 percent). There were no significant decreases in age-specific death rates for Hispanics between 2004 and 2005. Rates for Hispanic males increased for age groups under 1 year (5.3 percent), 15-24 years (4.4 percent), and 25-34 years (5.8 percent). For Hispanic females, the only significant change in age-specific rates was for the age group 15-24 years which increased 15.1 percent from 2004 to 2005.

### **Expectation of life at birth and at specified ages**

Life expectancy at birth represents the average number of years that a group of infants would live if the infants were to experience throughout life the age-specific death rates present in the year of birth. The life table methodology used to calculate the life expectancies shown in this report was revised beginning with the 1997 data year; see “[Technical Notes.](#)” The revised methodology provides values similar to the method used before 1997 but is more comparable to decennial life table methods, provides more accurate estimates, and provides

more age detail. In 2005, life expectancy at birth for the U.S. population was 77.8 years, the same as in 2004 (Tables 6–8). The trend in U.S. life expectancy since 1900 is one of gradual improvement.

In 2005, life expectancy for females was 80.4 years, and for males it was 75.2 years. Both are the same as in 2004. From 1900 to the late 1970s, the sex gap in life expectancy widened (Figure 3; data prior to 1975 not shown) from 2.0 years to 7.8 years. Since its peak in the 1970s, the sex gap has been narrowing (Figure 3). The difference in life expectancy between the sexes was 5.2 years in 2005.

Between 2004 and 2005, life expectancy increased 0.1 year for the black population to a record high of 73.2 years. Life expectancy for the white population remained the same as in 2004 at 78.3 years. The difference in life expectancy between the white and black populations in 2005 was 5.1 years, a 0.1-year decrease from the 2004 gap between the two races and was the smallest gap ever recorded. The white / black gap has been narrowing gradually from a peak of 7.1 years in 1989 to the current record low (Figure 3). This resumed a long-term decline in the white-black difference in life expectancy that was interrupted in the period from 1982 to 1989 when the gap widened.

Among the four major race-sex groups (Tables 7, 8, and Figure 4), white females continued to have the highest life expectancy at birth (80.8 years), followed by black females (76.5 years), white males (75.7 years), and black males (69.5 years). Life expectancies remained unchanged from 2004 for white males, white females and black males. Between 2004 and 2005, the only gain in life expectancy among the four race-sex groups was for black females (0.2 year). Life expectancy for black males declined every year from 1984 to 1989 then resumed the long-term trend of increase from 1990 to 1992 and 1994 to 2004 (Table 8). For white females, life expectancy increased most years from 1970 to 1998. In 1999, life expectancy for white females fell below 1998's record high level, but in 2000 life expectancy for this population began to rise again. Between 1988 and 1992, 1993 and 1994, and between 1995 and 1998, life expectancy for black females increased. In 1999, life expectancy for black females declined as it did for white females, only to begin to climb again in 2000.

Life tables shown in this report may be used to compare life expectancies at selected ages from birth to

100 years. For example, a person who has reached 65 years will live to an older age, on the average, than one who has reached 50 years. On the basis of mortality experienced in 2005, a person aged 50 years could expect to live an average of 30.9 more years for a total of 80.9 years. A person aged 65 years could expect to live an average of 18.7 more years for a total of 83.7 years, and a person aged 85 years could expect to live an average of 6.8 more years for a total of 91.8 years ([Tables 6 and 7](#)).

## **Leading causes of death**

The 15 leading causes of death in 2005 accounted for 82.3 percent of all deaths in the United States ([Table C](#)). Causes of death are ranked according to the number of deaths. For ranking procedures, see “[Technical Notes](#).” In rank order, the 15 leading causes in 2005 were: 1) Diseases of heart (heart disease), 2) Malignant neoplasms (cancer), 3) Cerebrovascular diseases (stroke), 4) Chronic lower respiratory diseases, 5) Accidents (unintentional injuries), 6) Diabetes mellitus (diabetes), 7) Alzheimer’s disease, 8) Influenza and pneumonia, 9) Nephritis, nephrotic syndrome and nephrosis (kidney disease), 10) Septicemia, 11) Intentional self-harm (suicide), 12) Chronic liver disease and cirrhosis, 13) Essential (primary) hypertension and hypertensive renal disease (hypertension), 14) Parkinson’s disease, and 15) Assault (homicide). The 15 leading causes of death in 2005 retained the same ranking as in 2004.

The age pattern of mortality can vary greatly by cause of death, and as a result, changes in crude death rates over time can be significantly influenced by the changing composition of the population. In contrast, age-adjusted death rates eliminate the influence of such shifts in the population age structure. Therefore, age-adjusted death rates are better indicators than crude rates for showing changes in mortality over time and among causes of death. Consequently, age-adjusted death rates are used to depict trends for leading causes of death ([Figure 5](#)).

Between 2004 and 2005, the number of deaths increased by 2.1 percent (50,402 more deaths). However, the age-adjusted death rate for all causes in the United States continued to decline, decreasing 0.2 percent from 2004 to 2005. This reduction in the risk of dying has been driven mostly by net decreases in the

leading causes of death such as heart disease, cancer, and stroke.

Among the 15 leading causes of death, the age-adjusted death rate declined significantly for 3 of the 15 leading causes of death (Table C). Long-term decreasing trends for heart disease, cancer, and stroke (the three leading causes of death) continued in 2005, with decreases relative to 2004 of 2.7 percent, 1.1 percent and 6.8 percent, respectively. Except for a relatively small increase in 1993, mortality from heart disease has steadily declined since 1980 (Figure 5). The age-adjusted death rate for cancer, the second leading cause of death, has shown a gradual but consistent downward trend since 1993 (Figure 5). The rate for stroke, the third leading cause of death, declined 6.8 percent between 2004 and 2005. At least part of this decline (perhaps as much as one-third) is due to changes in coding rules. The change in coding rules was implemented to eliminate conflicting instructions on selecting an underlying cause and prefer the instruction to select Multi-infarct dementia rather than stroke that resulted in Multi-infarct dementia, see “Technical Notes” for more detail. Stroke has generally declined since 1958, with one exception: an increase of 2.6 percent between the years 1992 and 1995 (Figure 5).

The age-adjusted death rates for the following seven leading causes of death increased significantly between 2004 and 2005: Chronic lower respiratory diseases (5.1 percent), unintentional injuries (3.7 percent), Alzheimer’s disease (5.0 percent), Influenza and pneumonia (2.5 percent), hypertension (3.9 percent), Parkinson’s disease (4.9 percent), and homicide (3.4 percent). The death rate for unintentional injuries generally declined by about half from a 40-year high in 1966 (67.6 deaths per 100,000 standard population) to a low of 33.2 in 1992. From then on, it has tended to increase gradually to current levels (Figure 5). Similarly, the age-adjusted death rate for hypertension declined sharply to a low of 3.2 deaths per 100,000 standard population in 1978. After a period of little variation during the 1980s, it started a gradual but constant rise to current levels.

In contrast to the pattern for unintentional injuries and hypertension, the mortality trend for Alzheimer’s disease is one of rapid increase (Figure 5). From 1979 until 1998, the rate for Alzheimer’s disease increased dramatically due to improvements in diagnosis, awareness of the condition within the medical community,

and other unidentified factors (23). The transition from ICD–9 to ICD–10 brought substantial changes to the coding and selection rules for this condition. This created a major disruption in the time series' trend for Alzheimer's disease between 1998 and 1999 (Figure 5). The large increase between 1998 and 1999 is at least partly due to the ICD transition (24). Evaluating the observed change poses a problem because the comparability ratio (representing the net effect of the new revision on cause-of-death statistics) for Alzheimer's disease may be understated (24-27). The age-adjusted death rate for Parkinson's disease increased by 4.9 percent from 2004 to 2005 and has generally been increasing for almost three decades (28).

Although mortality from Human immunodeficiency virus disease (HIV disease) has not been on the list of 15 leading causes of death since 1997 (29), it is still considered a major public health problem. In 2005, a total of 12,543 persons died from HIV disease (Table 10). The age-adjusted death rate (4.2 per 100,000 standard population; Table 16) declined for the tenth consecutive year, decreasing 6.7 percent between 2004 and 2005, the biggest decrease since 1999. Although, the age-adjusted death rate for this cause reached its highest point of 16.3 per 100,000 standard population in 1995 and declined by an average of 12.7 percent every year since then (30), the rate of decline in mortality for this cause of death has slowed from an average of 33.0 percent per year (1995-1998) to an average of 3.3 percent per year (1998-2005).

Changes in mortality levels by age and cause of death have an important effect on changes in life expectancy. Life expectancy at birth for all races, males, and females did not change between 2004 and 2005, remaining at 77.8, 75.2, and 80.4 years respectively (Table 8). Despite reductions in heart disease, cancer and stroke, life expectancy did not change for the population as a whole, or for males and females because of off-setting increases in mortality from Chronic lower respiratory diseases, unintentional injuries, Alzheimer's disease, Influenza and pneumonia, and homicide (data not shown). (For discussion of contributions to the change in life expectancy, see "Technical Notes.")

The relative risk of death in one population group compared with another can be expressed as a ratio. Ratios based on age-adjusted death rates show that males have higher rates than females for 12 of the 15 leading causes of death (Table C), with rates for males being at least 2 times those for females for five leading causes.



The largest ratio (4.1) was for suicide. Other large ratios were evident for homicide (3.8), Parkinson's disease (2.2), unintentional injuries (2.2), Chronic liver disease and cirrhosis (2.1), heart disease (1.5), and cancer (1.4).

The difference in life expectancy between males and females did not change between 2004 and 2005, remaining at 5.2 years. The lack of change in the difference between male and female life expectancy was an outcome of offsetting improvements in mortality from specific causes for both sexes. For example, males experienced greater improvements in mortality from heart disease, Influenza and pneumonia, Chronic lower respiratory diseases, and HIV disease than females; while females experienced greater improvements in mortality from cancer, diabetes, unintentional injuries, and homicide (data not shown).

Rates for the black population were at least 1.3 times that for the white population for seven of the 15 leading causes of death (Table C). The largest ratio was for homicide (5.7). Other causes for which the ratio was high include hypertension (2.6), kidney disease (2.3), Septicemia (2.2), diabetes (2.1), stroke (1.5), and heart disease (1.3). For five of the leading causes, age-adjusted rates were lower for the black population than for the white population. The smallest black-to-white ratios were for suicide and Parkinson's disease (0.4 each); that is, the risk of dying from suicide or Parkinson's disease is more than double for the white population than for the black population. Other conditions with a low black-to-white ratio were Chronic lower respiratory diseases (0.7), Alzheimer's disease and Chronic liver disease and cirrhosis (0.8 each).

The difference in life expectancy between blacks and whites narrowed from 5.2 years in 2004 to 5.1 years in 2005. The narrowing in the black-white life expectancy gap was due primarily to greater improvements in mortality for the black population than among the white population. In particular, the black population gained ground on the white population due to improvements in death rates for heart disease, cancer, diabetes, HIV disease, and Influenza and pneumonia (data not shown).

Age-adjusted death rates were lower for the Hispanic population for 11 of the 15 leading causes of death relative to the non-Hispanic white population (Table C). The smallest ratio was for Chronic lower respiratory diseases and suicide (0.4 each). Other causes for which the ratio was considerably smaller include heart disease and cancer (0.7 each), Alzheimer's disease and Parkinson's disease (0.6 each), stroke, unintentional injuries,

Influenza and pneumonia, and Septicemia (0.8 each). Age-adjusted death rates for the Hispanic population were greater than for the non-Hispanic white population for three of the 15 leading causes of death. The largest ratio was for homicide (2.8), followed by Chronic liver disease and cirrhosis and diabetes (1.6 each).

Leading causes of death for the total population and for specific subpopulations are examined in more detail in a separate National Vital Statistics Report on leading causes by age, race, Hispanic origin, and sex (6).

### **Cataclysmic storms**

Mortality due to cataclysmic storms increased substantially between 2004 and 2005. In 2005, 874 deaths were reported compared to 63 in 2004. In 2005, the age-adjusted death rate was 0.3 deaths per 100,000 standard population (data not shown). This increase largely reflects those deaths directly attributed to Hurricane Katrina in August 2005, but also Hurricane Rita in September and a tornado in Indiana in November. (For more information about deaths due to cataclysmic storms see “[Technical Notes](#).”)

### **Injury mortality by mechanism and intent**

In 2005, a total of 173,753 deaths were classified as injury-related ([Table 18](#)). Injury data are presented using the external cause of injury mortality matrix for ICD–10. The matrix was jointly conceived by the International Collaborative Effort (ICE) on Injury Statistics and the Injury Control and Emergency Health Services (ICEHS) section of the American Public Health Association ([31,32](#)). The two essential dimensions of the ICD codes for injuries form the basis for this framework: the mechanism of the injury and the manner or intent of the injury. The mechanism involves the circumstances of the injury (e.g., fall, motor vehicle accident, poisoning). The manner or intent of the injury involves whether the injury was inflicted purposefully or not (in some cases, intent cannot be determined) and, when intentional, whether the injury was self-inflicted (suicide) or inflicted upon another person (assault). In the list of 113 selected causes of death, the focus is on manner or intent with subcategories showing selected mechanisms. The matrix has two distinct advantages for the analysis of injury

mortality data. First, it contains a comprehensive list of mechanisms. Second, data can be displayed by mechanism with subcategories of intent (as in [Table 18](#)) or vice versa. Four major mechanisms of injury in 2005—motor-vehicle traffic, poisoning, firearm, and fall—accounted for 73.4 percent of all injury deaths.

*Motor vehicle traffic*—In 2005, motor-vehicle traffic-related injuries resulted in 43,667 deaths, accounting for 25.1 percent of all injury deaths ([Table 18](#)). The slight decrease in age-adjusted death rate for motor-vehicle traffic-related injuries from 2004 ([33](#)) to 2005 (from 14.7 per 100,000 U.S. standard population to 14.6) was not statistically significant.

*Poisoning*—In 2005, 32,691 deaths occurred as the result of poisonings, 18.8 percent of all injury deaths ([Table 18](#)). The majority of poisoning deaths were either unintentional (72.2 percent) or suicides (17.6 percent). However, a substantial proportion (9.9 percent) of poisonings was of undetermined intent. From 2004 to 2005 the age-adjusted death rate for poisoning increased by 6.8 percent from 10.3 per 100,000 U.S. standard population to 11.0. Unintentional poisoning death rates in the United States have increased each year from 1999 to 2005 (data prior to 2005 not shown).

*Firearm*—In 2005, 30,694 persons died from firearm injuries in the United States ([Tables 18–20](#)), accounting for 17.7 percent of all injury deaths in 2005. Firearm suicide and homicide, the two major component causes, accounted for 55.4 and 40.2 percent, respectively, of all firearm injury deaths in 2005. From 2004 to 2005 the age-adjusted death rate for firearm injuries increased by 2.0 percent from 10.0 per 100,000 U.S. standard population to 10.2 ([Tables 18-20](#)). In 2005, males had a firearm-related, age-adjusted death rate that was 6.8 times that for females, the black population had a rate that was 2.2 times that for the white population. The non-Hispanic white population had a rate that was 1.2 times that for the Hispanic population, and the non-Hispanic black population had a rate that was 2.6 times that for the Hispanic population ([Tables 19 and 20](#)).

*Falls*—In 2005, 20,426 persons died as the result of falls, 11.8 percent of all injury deaths ([Table 18](#)). The overwhelming majority (96.2 percent) of fall-related deaths were unintentional. From 2004 ([33](#)) to 2005 the age-adjusted death rate for falls increased by 1.5 percent from 6.5 per 100,000 U.S. standard population to 6.6;

however, this was not a statistically significant difference.

More detailed information on injury deaths, including data by age, race, Hispanic origin, sex, and state are presented in a separate report (7). Also presented in this separate report are data describing the nature of injury sustained and type of poison.

### **Drug-induced mortality**

In 2005, a total of 33,541 persons died of drug-induced causes in the United States (Tables 21 and 22). The category “drug-induced causes” includes not only deaths from dependent and nondependent use of either legal or illegal drugs, but also poisoning from medically prescribed and other drugs. It excludes unintentional injuries, homicides, and other causes indirectly related to drug use. Also excluded are newborn deaths due to mother’s drug use. (For a list of drug-induced causes, see “Technical Notes.”) In 2005, the age-adjusted death rate for drug-induced causes for males was 1.8 times the rate for females. The age-adjusted death rate for the white population was 1.1 times the rate for the black population (Table 21). The rate for the non-Hispanic white population was 1.9 times that of the Hispanic population and the rate for the non-Hispanic black population was 1.7 times that of the Hispanic population (Table 22). Between 2004 and 2005, the age-adjusted death rate for drug-induced causes increased 8.7 percent from 10.4 deaths per 100,000 U.S. standard population to 11.3. Between 2004 and 2005, the age-adjusted death rate for drug-induced causes among the major ethnic-race-sex groups increased by 8.6 percent for white males, 7.4 percent for white females, 10.5 percent for black males, 9.1 percent for black females and 12.4 percent for Hispanic males. For Hispanic females the age adjusted death rate increased 2.9 percent but this was not statistically significant.

### **Alcohol-induced mortality**

In 2005, a total of 21,634 persons died of alcohol-induced causes in the United States (Tables 23 and 24). The category “alcohol-induced causes” includes not only deaths from dependent and nondependent use of alcohol, but also accidental poisoning by alcohol. It excludes unintentional injuries, homicides, and other

causes indirectly related to alcohol use as well as deaths due to fetal alcohol syndrome. (For a list of alcohol-induced causes, see “[Technical Notes.](#)”) In 2005 the age-adjusted death rate for alcohol-induced causes for males was 3.2 times the rate for females, and the rate for the Hispanic population was 1.3 times the rate for the non-Hispanic white population ([Tables 23](#) and [24](#)). Between 2004 and 2005, the age-adjusted death rate for alcohol-induced causes for the total population remained unchanged statistically (7.0 per 100,000 U.S. standard population). Among the major race-sex groups, the rate significantly changed for black males. Among the major race-ethnic-sex groups, the rate significantly changed for black males and non-Hispanic black males, decreasing 7.3 and 7.2 percent, respectively, and for Hispanic males, increasing 7.3 percent.

### **Marital status**

For those aged 15 years and over, the number of deaths in 2005 of persons who were married was 929,991; widowed, 908,645; divorced, 300,290; and never married, 257,695 ([Table 25](#)); see “[Technical Notes.](#)” Those who never married had the highest age-adjusted death rate, followed by widowed, divorced, and married persons, respectively. The never-married group had an age-adjusted death rate 63.2 percent higher than the ever-married and 2.2 times the rate for the currently married. Age-adjusted death rates for the widowed were 93.8 percent higher than for those who were currently married at the time of death. Divorced persons had a rate 92.8 percent higher than those who were married at the time of death.

For all age groups 15 years and over, death rates for married persons were much lower than those for never-married persons. For ages 15–24 years divorced persons had the highest death rate, while at ages 25–34 years, widowed persons had the highest death rate. For ages 35–44 years, 45–54 years, 55–64 years, and 75 years and over, those who never married had the highest death rates. For ages 65–74 years, divorced had the highest death rate.

For each marital status group in 2005, males had higher age-adjusted death rates than females, ranging from 30.6 percent greater for the never-married to 76.7 percent greater for those married at the time of death.

## **Educational attainment**

Age-specific and age-adjusted death rates are shown by educational attainment for age groups in the range 25–64 years ([Table 26](#)). In the 31 reporting states, a total of 148,051 decedents aged 25–64 years had completed 12 years of education compared with 103,913 who had completed 13 years or more and 73,090 who had completed fewer than 12 years. For the total population, and for males and females separately, mortality is inversely associated with educational attainment; that is, the average risk of death decreases markedly with increasing educational attainment. The age-adjusted death rate for those with less than 12 years of education was 650.4 per 100,000 U.S. standard population—36.2 percent higher than the rate of 477.6 for those with 12 years of education and 3.2 times the rate for those with 13 years of education or more.

Rates are shown only for ages 25–64 years because persons under age 25 may not have completed their education. Rates are not shown for the older ages because of misreporting of educational attainment on the death certificate; see “[Technical Notes](#).” Data on educational attainment must be interpreted with caution because of misreporting on the death certificate and biases that result from differences between the classification of educational attainment on the death certificate and in census surveys; see “[Technical Notes](#).”

## **Injury at work**

For persons aged 15 years and over, a total of 5,113 deaths were reported on the death certificates to be due to injuries at work ([Table 27](#)). Rates were lowest for age groups 15–24 years and 65 years and over. The risk of work-related death was much greater for males than for females; the age-adjusted death rate for males was 4.1 deaths per 100,000 U.S. standard population compared with 0.4 for females, resulting in a mortality ratio of about 10 to 1. The age-adjusted rate for the white population (2.3) was slightly higher than the rate for the black population (2.0). The male-to-female ratios for the white and black populations were 10.5 and 10.0, respectively.

The number of deaths due to injury at work decreased by 44 between 2004 to 2005. The age-adjusted death

rate of injury at work for the population aged 15 years and over decreased 4.5 percent between 2004 and 2005 ([Table 28](#)). For specific sex and race groups, the age-adjusted death rate decreased for white males (4.5 percent) and increased for white females (33.3 percent) but did not change significantly for black males and was unchanged for black females.

### **State of residence**

Mortality patterns vary considerably by state ([Table 29](#)). The state with the highest age-adjusted death rate in 2005 was Mississippi (1026.9 per 100,000 standard population) with a rate 28.6 percent above the national average. The state with the lowest age-adjusted death rate was Hawaii (609.0 per 100,000 standard population), with a rate 23.8 percent below the national average.

Variations in mortality by state are associated with differences in socioeconomic status, race, and ethnic composition as well as differences in risk for specific causes of death ([34](#)).

### **Infant mortality**

In 2005, a total of 28,440 deaths occurred in children under 1 year ([Table D](#)), 504 more deaths than in 2004. The infant mortality rate, the neonatal mortality rate (deaths to infants aged 0–27 days per 1,000 live births), and the postneonatal mortality rate (deaths to infants aged 28 days–1 year per 1,000 live births), in 2005, were 6.87, 4.54, and 2.34 deaths per 1,000 live births, respectively (see “[Technical Notes](#)” for information on alternative data sources) ([Table 30](#) and [Figure 6](#)). The changes in the infant and neonatal mortality rates between 2004 and 2005 were not statistically significant; however, the postneonatal mortality rate increased 3.1 percent from 2.27 in 2004 to 2.34 in 2005 for all races combined. Rates also increased significantly for male postneonates for all races combined (4.0 percent) and white postneonates (3.7 percent).

The 10 leading causes of infant death in 2005 accounted for 68.1 percent of all infant deaths in the United States ([Table E](#)). In rank order, the 10 leading causes were: 1) Congenital malformations, deformations and chromosomal abnormalities (congenital malformations), 2) Disorders related to short gestation and low birth

weight, not elsewhere classified (low birthweight), 3) Sudden infant death syndrome (SIDS), 4) Newborn affected by maternal complications of pregnancy (maternal complications), 5) Newborn affected by complications of placenta, cord and membranes (cord and placental complications), 6) Accidents (unintentional injuries), 7) Respiratory distress of newborn, 8) Bacterial sepsis of newborn, 9) Neonatal hemorrhage, and 10) Necrotizing enterocolitis of newborn. The 10 leading causes remained nearly the same as in 2004 with the following exceptions: in 2005, cord and placental complications and unintentional injuries exchanged positions with each other relative to their positions in 2004 (33) and Necrotizing enterocolitis of newborn replaced Diseases of the circulatory system as the 10<sup>th</sup> leading cause of death among infants.

Changes in rates by cause of death among the 10 leading causes were statistically significant for one condition, Necrotizing enterocolitis of newborn, which increased by 23.4 percent between 2004 and 2005 (Table E). This relatively large increase is due to a change in coding rules that results in Necrotizing enterocolitis of newborn being selected as the underlying cause more often than was previously the case; see “Technical Notes.”

The ratio of the male-to-female infant mortality rates and the black-to-white infant mortality rates were 1.2 and 2.4, respectively, in 2005, the same as in 2004. Race cited on the death certificate is considered to be relatively accurate for white and black infants (19). However, for other race groups, race may be misreported on the death certificate (35); consequently, the reader is directed to the forthcoming report using data from the linked file of live births and infant deaths for better measures of race and infant mortality (36). (See “Technical Notes.”)

*Hispanic infant mortality*—The infant mortality rate for Hispanic infants and non-Hispanic white infants were 5.81 and 5.71 deaths per 1,000 live births, respectively, in 2005 (data not shown). Among Hispanic subgroups, infant mortality rates for Puerto Rican, Mexican, Cuban, and Central and South American infants were 7.66, 5.92, 3.80, and 3.00 deaths per 1,000 live births, respectively. Increases between 2004 and 2005 for Central and South American largely reflects improvements in identification; see “Technical Notes.” None of the other Hispanic infant mortality rates changed by a statistically significant amount from 2004 to 2005. Infant



mortality rates by specified Hispanic origin and race for non-Hispanic origin are somewhat understated and are better measured using data from the linked file of live births and infant deaths (35); see “[Technical Notes](#).”

## **Maternal mortality**

In 2005, a total of 623 women were reported to have died of maternal causes ([Tables 33](#) and [34](#)). As in previous years, the number of maternal deaths does not include all deaths occurring to pregnant women, but only those deaths reported on the death certificate that were assigned to causes related to or aggravated by pregnancy or pregnancy management (ICD–10 codes A34, O00-O95, and O98-O99). Further, the number excludes deaths occurring more than 42 days after the termination of pregnancy and deaths of pregnant women due to external causes (unintentional injuries, homicides, and suicides) (9). An increasing number of states are adopting a separate item on the death certificate indicating pregnancy status of the decedent to improve measurement; see “[Technical Notes](#).” The number of areas with such an item has increased from 16 states in 1996 to 31 states and the District of Columbia in 2005.

The maternal mortality rate for 2005 was 15.1 deaths per 100,000 live births. Black women have a substantially higher risk of maternal death than white women. The maternal mortality rate for black women was 36.5, roughly 3.3 times the rate for white women (11.1 deaths per 100,000 live births).

*Hispanic maternal mortality*—The maternal mortality rate for Hispanic women was 9.6 deaths per 100,000 live births. The non-Hispanic-white maternal mortality rate was 11.7 in 2005. The difference between the Hispanic and non-Hispanic white rates was not statistically significant. As with other statistics involving Hispanic origin, these should be interpreted with caution because of inconsistencies between reporting Hispanic origin on death certificates and on censuses and surveys; see “[Technical Notes](#).”

## Technical notes

### Nature and sources of data

Data in this report are based on information from all death certificates filed in the 50 states and the District of Columbia and are processed by the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS). Data for 2005 are based on records of deaths that occurred during 2005 and were received as of March 31, 2006. The U.S. Standard Certificate of Death--which is used as a model by the states--was revised in 2003 (37). Prior to 2003, the Standard Certificate of Death had not been revised since 1989. This report includes data for 17 states (California, Connecticut, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New York, Oklahoma, South Carolina, South Dakota, Utah, Washington, and Wyoming), which used the 2003 revision of the U.S. Standard Certificate of Death in 2005 for the entire year, for the District of Columbia which implemented the 2003 revision for part of 2005, and for the remaining 33 states that collected and reported death data in 2005 based on the 1989 revision of the U.S. Standard Certificate of Death. Data for the District of Columbia were collected and reported using the 1989 revision until March when they began using the 2003 revision. The 1989 and 2003 revisions are described in detail elsewhere (37-40).

Since most of the items presented in this report appear largely comparable despite changes to item wording and format in the 2003 revision, data from both groups of states are combined unless otherwise stated. Data for Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Northern Marianas are included in tables showing data by state, but are not included in U.S. totals.

Mortality statistics are based on information coded by the states and provided to the National Center for Health Statistics (NCHS) through the Vital Statistics Cooperative Program (VSCP) and from copies of the original certificates received by NCHS from the state registration offices. In 2005 all the states and the District of Columbia participated in this program and submitted part or all of the mortality data for 2005 in electronic data files to NCHS. All areas provided precoded medical (cause-of-death) data to NCHS except Illinois, New

Jersey, and West Virginia. Louisiana provided precoded medical data to NCHS for part of the year. For 2005, all states submitted precoded demographic data for all deaths.

Data for the entire United States refer to events occurring within the United States. Data shown for geographic areas are by place of residence. Beginning with 1970, mortality statistics for the United States exclude deaths of nonresidents of the United States. All data exclude fetal deaths.

Mortality statistics for Puerto Rico, Virgin Islands, American Samoa, and Northern Marianas exclude deaths of nonresidents of Puerto Rico, Virgin Islands, American Samoa, and Northern Marianas, respectively. For Guam, however, mortality statistics exclude deaths that occurred to a resident of any place other than Guam or the United States.

### **Cause-of-death classification**

The mortality statistics presented in this report were compiled in accordance with World Health Organization (WHO) regulations, which specify that member nations classify and code causes of death in accordance with the current revision of the *International Classification of Diseases* (ICD). The ICD provides the basic guidance used in virtually all countries to code and classify causes of death. Effective with deaths occurring in 1999, the United States began using the Tenth Revision of this classification (ICD-10) (9). For earlier years causes of death were classified according to the revisions then in use--1979-98, Ninth Revision; 1968-78, Eighth Revision, adapted for use in the United States; 1958-67, Seventh Revision; and 1949-57, Sixth Revision.

Changes in classification of causes of death due to these revisions may result in discontinuities in cause-of-death trends. Consequently, cause-of-death comparisons among revisions require consideration of comparability ratios and, where available, estimates of their standard errors. Comparability ratios between the Ninth and Tenth Revisions, between the Eighth and Ninth Revisions, between the Seventh and Eighth Revisions, and between the Sixth and Seventh Revisions may be found in other NCHS reports and independent tabulations (25-27,41-43).

Rules for coding a cause(s) of death may sometimes require modification when evidence suggests that such modifications will improve the quality of cause-of-death data. Prior to 1999, such modifications were made only when a new revision of the ICD was implemented. A process for updating the ICD was introduced with ICD-10 that allows for mid-revision changes. These changes, however, may affect comparability of data between years for select causes of death. Minor changes may be implemented every year while major changes may be implemented every three years (e.g., 2003 data year).

The ICD not only details disease classification but also provides definitions, tabulation lists, the format of the death certificate, and the rules for coding cause of death. Cause-of-death data presented in this publication were coded by procedures outlined in annual issues of the *NCHS Instruction Manual* (44,45). It includes rules for selecting the underlying cause of death, definitions, tabulation lists, and regulations on the use of the ICD.

Before data for 1968, mortality medical data were based on manual coding of an underlying cause of death for each certificate in accordance with WHO rules. Effective with data year 1968, NCHS converted to computerized coding of the underlying cause and manual coding of all causes (multiple causes) on the death certificate. In this system, called “Automated Classification of Medical Entities” (ACME) (46), multiple cause codes serve as inputs to the computer software that employs WHO rules to select the underlying cause. All cause-of-death data in this report are coded using ACME.

The ACME system is used to select the underlying cause of death for all death certificates in the United States. In addition, NCHS has developed two computer systems as inputs to ACME. Beginning with 1990 data, the Mortality Medical Indexing, Classification, and Retrieval system (MICAR) (47,48), was introduced to automate coding multiple causes of death. In addition, MICAR provides more detailed information on the conditions reported on death certificates than is available through the ICD code structure. Then, beginning with data year 1993, SuperMICAR, an enhancement of the MICAR system, was introduced. SuperMICAR allows for literal entry of the multiple cause-of-death text as reported by the certifier. This information is then automatically processed by the MICAR and ACME computer systems. Records that cannot be automatically processed by MICAR or SuperMICAR are manually multiple-cause coded and then further processed through

ACME. For 2005, all of the Nation's death records were multiple-cause coded using SuperMICAR.

In this report tabulations of cause-of-death statistics are based solely on the underlying cause of death. The underlying cause is defined by WHO as “the disease or injury which initiated the train of events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury” (9). It is selected from the conditions entered by the physician in the cause-of-death section of the death certificate. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. Generally, more medical information is reported on death certificates than is directly reflected in the underlying cause of death. This is captured in NCHS multiple cause-of-death statistics (49-51).

### **Tabulation lists and cause-of-death ranking**

Tabulation lists for ICD-10 are published in the NCHS Instruction Manual, Part 9, ICD-10 Cause-of-Death Lists for Tabulating Mortality Statistics (Updated October 2002) (52). For this report, two tabulation lists are used, namely, the List of 113 Selected Causes of Death used for deaths of all ages, and the List of 130 Selected Causes of Infant Death used for infants. These lists are also used to rank leading causes of death for the two population groups. For the List of 113 Selected Causes of Death, the group titles Major cardiovascular diseases (ICD-10 codes I00-I78) and Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (ICD-10 codes R00-R99) are not ranked. In addition, category titles that begin with the words “Other” and “All other” are not ranked to determine the leading causes of death. When one of the titles that represents a subtotal is ranked (for example, Tuberculosis (ICD-10 codes A16-A19)), its component parts are not ranked (in this case, Respiratory tuberculosis (ICD-10 code A16) and Other tuberculosis (ICD-10 codes A17-A19)). For the List of 130 Selected Causes of Infant Death, the same ranking procedures are used, except that the category Major cardiovascular diseases is not in the list. More detail regarding ranking procedures can be found in “Deaths: Leading Causes for 2005” (6).

Leading cause-of-death trends, discussed in this report, are based on cause-of-death data according to ICD-

10 for 1999-2005, and on data for the most comparable ICD-9 cause-of-death titles for 1979-1998. Tables showing ICD-9 categories that are comparable to the ICD-10 titles in the list of 113 selected causes of death may be found in "Comparability of Cause of Death Between ICD-9 and ICD-10: Preliminary Estimates" (27) and "Deaths: Final Data for 1999" (24). Although in some cases categories from the list of 113 selected causes are identical to those in the old list of 72 selected causes of death used with ICD-9, it is important to note that many of these categories are not comparable with categories in the list of 72 selected causes even though the cause-of-death titles may be the same.

Trend data for 1979-1998 that are classified by ICD-9 but sorted into the list of 113 selected causes of death developed for ICD-10 can be found on the mortality website at <http://www.cdc.gov/nchs/data/statab/hist001r.pdf>.

Revision of the ICD and resulting changes in classification and rules for selecting the underlying cause of death have important implications for the analysis of mortality trends by cause of death. For some causes of death the discontinuity in trend can be substantial (26,27). Therefore, considerable caution should be used in analyzing cause-of-death trends for periods of time that extend across more than one revision of the ICD.

### **Cataclysmic storms**

The increase in mortality due to cataclysmic storms (ICD-10 code X37) largely reflects those deaths directly attributed to Hurricane Katrina in August 2005, but also Hurricane Rita in September and a tornado in Indiana in November. Although the number of deaths due to cataclysmic storms is not shown separately in the tables of this report, the deaths are included in the broader category, Other and unspecified nontransport accidents and their sequelae (ICD-10 codes W20-W31,W35-W64,W75-W99,X10-X39,X50-X59,Y86).

Deaths reported to NCHS that were certified as due to Hurricane Katrina are likely to underestimate the actual number of deaths attributable to the storm (53). Deaths were attributed to a cataclysmic storm only if the storm was explicitly reported as a cause of death on the death certificate.

## Codes for terrorism

Beginning with data for 2001, NCHS introduced categories \*U01-\*U03 for classifying and coding deaths due to acts of terrorism. The asterisks before the category codes indicate that they are not part of the *International Classification of Diseases, Tenth Revision* (ICD-10). Deaths classified to the terrorism categories are included in the categories for Assault (homicide) and Intentional self-harm (suicide) in the 113 cause-of-death list and in the category for Assault (homicide) in the 130 cause-of-death list for infants. Additional information on these new categories can be found at [http://www.cdc.gov/nchs/about/otheract/icd9/terrorism\\_code.htm](http://www.cdc.gov/nchs/about/otheract/icd9/terrorism_code.htm).

## Race and Hispanic origin

The 2003 revision of the U.S. Standard Certificate of Death allows the reporting of more than one race (multiple races) (37). This change was implemented to reflect the increasing diversity of the population of the United States and to be consistent with the decennial census. The race and ethnicity items on the revised certificate are compliant with the 1997 revision of the Race and Ethnic Standards for Federal Statistics and Administrative Reporting. These were issued by the Office of Management and Budget (OMB), and have replaced the previous standards that were issued in 1977 (11). The new standards mandate the collection of more than one race where applicable for Federal data (10). In addition, the new certificate is compliant with the OMB-mandated minimum set of five races to be reported for Federal data. Multiple race includes any combination of white, black or African American, American Indian or Alaskan Native (AIAN), Asian, and Pacific Islander. If two or more specific subgroups such as Korean and Chinese are reported, these count as a single race of Asian rather than as multiple races.

In 2003 multiple race was reported on the revised death certificates of California, Idaho, Montana, and New York, as well as on the unrevised certificates of Hawaii, Maine, and Wisconsin.

In 2004 multiple race was reported for the entire year on the revised death certificates of California, Idaho,

Michigan, Montana, New Jersey, New York, Oklahoma, South Dakota, Washington, and Wyoming, as well as on the unrevised certificates of Hawaii, Maine, Minnesota, and Wisconsin. New Hampshire began reporting multiple race in mid-April of 2004 when they implemented the revised certificate.

In 2005 multiple race was reported for the entire year on the revised death certificates of California, Connecticut, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New York, Oklahoma, South Carolina, South Dakota, Utah, Washington, and Wyoming as well as on the unrevised certificates of Hawaii, Maine, Minnesota, and Wisconsin. The District of Columbia began reporting multiple race in March 2005 when they started implementing the revised certificate. The following computations, as well as figures shown in [Table I](#), exclude data for the District of Columbia because the District of Columbia did not report multiple race for the entire data year. More than one race was reported for 0.4 percent of the records in the 21 multiple race reporting states. While still uncommon, multiple races were reported more often for younger decedents than older decedents (2.4% of decedents under 25 years of age versus 0.6% of decedents between 25 and 64 years of age and 0.3% of decedents 65 years of age and older). No decedent was reported as having more than four races. Of those records where more than one race was reported, the Pacific Islander category was mentioned in combination with another race (48.3 percent) more often than the other categories (white, 0.4; black, 0.8; Asian, 5.1; American Indian, 18.6 percent).

Data from the vital records of the remaining 29 states are based on the 1989 revision of the U.S. Standard Certificate of Death and following the 1977 OMB standard, allowing only a single race to be reported ([11,40](#)). In addition, these states report a minimum set of four races as stipulated in the 1977 standard. These are white, black or African American, American Indian or Alaskan Native (AIAN), and Asian or Pacific Islander (API).

In order to provide uniformity and comparability of the data during the transition period, before all or most of the data are available in the new multiple-race format, it was necessary to “bridge” the responses of those for whom more than one race was reported (multiple race) to one, single race. The bridging procedure is similar to the procedure used to bridge multiracial population estimates ([13,14](#)). Multiracial decedents are imputed to a single race (either white, black, AIAN, or API) according to their combination of races, Hispanic origin, sex, and age indicated on the death certificate. The imputation procedure is described in detail at



Race and Hispanic origin are reported separately on the death certificate. Therefore, data shown by race include persons of Hispanic and non-Hispanic origin, and data for Hispanic origin include persons of any race. In this report, unless otherwise specified, deaths of Hispanic origin are included in the totals for each race group --- white, black, American Indian, and Asian or Pacific Islander (API) --- according to the decedent's race as reported on the death certificate. Data shown for Hispanic persons include all persons of Hispanic origin of any race.

Mortality data for the Hispanic-origin population are based on deaths to residents of all 50 states and the District of Columbia. Data year 1997 was the first year that mortality data for the Hispanic population were available for the entire United States.

*Quality of race and Hispanic origin data*--Death rates for Hispanic, American Indian, and API persons should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate as compared with race on censuses, surveys, and birth certificates. Studies have shown under-reporting on death certificates of American Indians, API, and Hispanic decedents; and undercounts of these groups in the censuses (19,54,55).

A number of studies have been conducted on the reliability of race reported on the death certificate by comparing race on the death certificate with that reported on another data collection instrument, such as the Census or a survey (19,54,55). Differences may arise because of differences in who provides race information on the compared records. Race information on the death certificate is reported by the funeral director as provided by an informant or, in the absence of an informant, on the basis of observation. In contrast, race on the census or on the Current Population Survey (CPS) is obtained while the individual is alive and is self-reported or reported by another member of the household familiar with the individual and, therefore, may be considered more valid. A high level of agreement between the death certificate and the census or survey report is essential to assure unbiased death rates by race.

Studies (19,54,55) show that a person self-reported as American Indian or Asian on census or survey records was sometimes reported as white on the death certificate. The net effect of misclassification is an underestimation

of deaths and death rates for races other than white and black. In addition, undercoverage of minority groups in the census and resultant population estimates, introduces biases into death rates by race (19, 54-57). Unlike the 1990 Census, coverage error in the 2000 Census was found to be statistically significant only for the non-Hispanic white and non-Hispanic black populations, with the former having been over counted by approximately 1.13 percent and the latter under-counted by approximately 1.84 percent (56).

Using the National Longitudinal Mortality Study (NLMS) Arias, et al., examined the reliability of race and Hispanic origin reported on approximately 250,000 death certificates with that reported on a total of 26 Current Population Surveys conducted by the U.S. Bureau of the Census for the years 1979-1998 (19). Agreement between the two sources was found to be excellent for the white and black populations, both exhibiting CPS to death certificate ratios of 1.00. On the other hand, substantial differences were found for other race groups. The ratio of CPS to death certificates was found to be 1.30 for the AIAN population and 1.07 for the API population, indicating net under-reporting on death certificates of 30 and 7 percent for these groups, respectively. The ratio of deaths for CPS to death certificates for Hispanics was found to be 1.05 percent, indicating a net under-report on death certificates for the Hispanic population of 5 percent.

Data on Central and South American and Other Hispanic origin are affected by whether a state submits literal text to NCHS, thereby making it possible to identify decedents as being of Central and South American origin. In 2005, California began submitting literal text, accounting for most of the increase in Central and South American deaths from 2004 to 2005.

*Other races and race not stated*--Beginning in 1992 all records coded as "Other races" (0.23 percent of the total deaths in 2005) were assigned to the specified race of the previous record. Records for which race was unknown, not stated, or not classifiable (0.12 percent) were assigned the racial designation of the previous record.

*Infant and maternal mortality rates*--For 1989-2005, as in previous years, infant and maternal deaths continue to be tabulated by the race of the decedent. However, beginning with the 1989 data year, the method of tabulating live births by race was changed from race of parents to race of mother as stated on the birth certificate. This change affects infant and maternal mortality rates because live births are the denominators of these rates (39,58). To improve continuity and ease of interpretation, trend data by race in this report have been retabulated by race of

mother for all years beginning with the 1980 data year.

Quantitatively, the change in the basis for tabulating live births by race results in more white births and fewer black births and births of other races. Consequently, infant and maternal mortality rates under the new tabulating procedure tend to be about 2 percent lower for white infants and about 5 percent higher for black infants than when they are computed by the previous method of tabulating live births by race of parents. Rates for most other minority races also are higher when computed by race of mother (59,60).

Infant mortality rates for the Hispanic-origin population are based on numbers of resident infant deaths reported to be of Hispanic origin and numbers of resident live births by Hispanic origin of mother for the United States. In computing infant mortality rates, deaths and live births of unknown origin are not distributed among the specified Hispanic and non-Hispanic groups. In 2005 the percent of infant deaths of unknown origin was 0.8 and the percent of live births to mothers of unknown origin was 0.7 for the United States.

Small numbers of infant deaths for specific Hispanic-origin groups result in infant mortality rates subject to relatively large random variation (see "Random variation"). Infant mortality rates by Hispanic origin are less subject to reporting error when based on linked files of infant deaths and live births (35,36).

Infant mortality rates calculated from the general mortality file for specified race and/or Hispanic origin contain errors because of reporting problems that affect the classification of race and Hispanic origin on the birth and death certificates for the same infant. Infant mortality rates by specified race and Hispanic origin are more accurate when based on the linked file of infant deaths and live births (35,36). The linked file computes infant mortality rates using the race and/or Hispanic origin of the mother from the birth certificate in both the numerator and denominator of the rate. In addition, mother's race and/or Hispanic origin from the birth certificate is considered to be more accurately reported than infant's race and/or Hispanic origin from the death certificate because, on the birth certificate, race is generally reported by the mother at the time of delivery whereas, on the death certificate, infant's race and/or Hispanic origin is reported by an informant, usually the mother but sometimes by the funeral director. Estimates of reporting errors have been made by comparing rates based on the linked files with those in which the race of infant death is based on information from the death certificate (35,54).

## Life tables

The life table provides a comprehensive measure of the effect of mortality on life expectancy. It is composed of sets of values showing the mortality experience of a hypothetical group of infants born at the same time and subject throughout their lifetime to the age-specific death rates of a particular time period, usually a given year. Beginning with final data reported for 1997, the life table methodology was changed from previous annual reports. Previously, U.S. life tables were abridged and constructed by reference to a standard table (59). In addition, the age range for these life tables was limited to 5-year age groups ending with the age group 85 years and over.

For data years 1997-1999, a revised life table methodology was used to construct complete life tables by single years of age that extend to age 100 (62) using a methodology similar to that of the decennial life tables (63). The advantages of the revised methodology are its comparability with decennial life table methodology, greater accuracy, and greater age detail. A comparison of the two methods shows small differences in resulting values for life expectancy (62). Although the revised method produces complete life tables, that is, life tables by single years of age, life table data shown in this report are summarized in 5-year age groupings. To calculate the probability of dying at each age, the revised methodology uses vital statistics death rates for ages under 85 years and mortality data from the Medicare program for ages 85 years and over. Medicare data were used to model the probability of dying at ages 85 and over because the data are shown to be significantly more reliable than vital statistics data at the oldest ages (64).

Because population estimates in single-years for ages 85 and older were unavailable for 2000-2002, life tables for these years used a slight modification of the life table method.

Beginning with the 2003 data year, the methodology developed in 1997 was used without the modification used from 2000-2002, as population estimates in single-years for ages 85 and older became available from Census. For data year 2005, pooled 1999-2001 Medicare data were used to model the probability of dying at ages 85 and over.

## **Causes of death contributing to changes in life expectancy**

Causes of death contributing to changes in life expectancy were estimated using a life table partitioning technique. The method partitions changes into component additive parts and identifies the causes of death having the greatest influence, positive or negative, on changes in life expectancy (20,65,66).

## **Injury mortality by mechanism and intent**

Injury mortality data are presented using the External cause of injury mortality matrix for ICD-10, in table 18. In this framework, causes of injury deaths are organized principally by mechanism (e.g. firearm or poisoning), and secondarily by manner, or intent of death (e.g. unintentional, suicide, homicide, etc.).

The number of deaths for selected causes in this framework may differ from those shown in tables that use the standard mortality tabulation lists. Following WHO conventions, standard mortality tabulations (table 10) present external causes of death (ICD-10 codes \*U01-\*U03,V01-Y89). In contrast, the matrix (Table 18) excludes deaths classified to Complications of medical and surgical care (ICD-10 codes Y40-Y84,Y88). For additional information on injury data presented in this framework, see <http://www.cdc.gov/nchs/about/otheract/ice/matrix10.htm> and “Deaths: Injuries, 2005” (7).

## **Codes for firearm deaths**

Causes of death attributable to firearm mortality include ICD-10 codes \*U01.4, Terrorism involving firearms (homicide); W32-W34, Accidental discharge of firearms; X72-X74, Intentional self-harm (suicide) by discharge of firearms; X93-X95, Assault (homicide) by discharge of firearms; Y22-Y24, Discharge of firearms, undetermined intent; and Y35.0, Legal intervention involving firearm discharge. Deaths from injury by firearms exclude deaths due to explosives and other causes indirectly related to firearms.

## Codes for drug-induced deaths

The list of codes included in drug-induced causes was expanded in the 2003 data year to be more comprehensive. Causes of death attributable to drug-induced mortality include ICD-10 codes D52.1, Drug-induced folate deficiency anemia; D59.0, Drug –induced hemolytic anemia; D59.2, Drug-induced nonautoimmune hemolytic anemia; D61.1, Drug-induced aplastic anemia; D64.2, Secondary sideroblastic anemia due to drugs and toxins; E06.4, Drug-induced thyroiditis; E16.0, Drug-induced hypoglycemia without coma; E23.1, Drug-induced hypopituitarism; E24.2, Drug-induced Cushing’s syndrome; E27.3, Drug-induced adrenocortical insufficiency; E66.1, Drug-induced obesity; selected codes from the ICD-10 title Mental and behavioral disorders due to psychoactive substance use, specifically, F11.0-F11.5, F11.7-F11.9, F12.0-F12.5, F12.7-F12.9, F13.0-F13.5, F13.7-F13.9, F14.0-F14.5, F14.7-F14.9, F15.0-F15.5, F15.7-F15.9, F16.0-F16.5, F16.7-F16.9, F17.0, F17.3-F17.5, F17.7-F17.9, F18.0-F18.5, F18.7-F18.9, F19.0-F19.5, F19.7-F19.9; G21.1, Other drug-induced secondary parkinsonism; G24.0, Drug-induced dystonia; G25.1, Drug-induced tremor; G25.4, Drug-induced chorea; G25.6, Drug-induced tics and other tics of organic origin; G44.4, Drug-induced headache, not elsewhere classified; G62.0, Drug-induced polyneuropathy; G72.0, Drug-induced myopathy; I95.2, Hypotension due to drugs; J70.2, Acute drug-induced interstitial lung disorders; J70.3, Chronic drug-induced interstitial lung disorders; J70.4, Drug-induced interstitial lung disorder, unspecified; L10.5, Drug-induced pemphigus; L27.0, Generalized skin eruption due to drugs and medicaments; L27.1, Localized skin eruption due to drugs and medicaments; M10.2, Drug-induced gout; M32.0, Drug-induced systemic lupus erythematosus; M80.4, Drug-induced osteoporosis with pathological fracture; M81.4, Drug-induced osteoporosis; M83.5, Other drug-induced osteomalacia in adults; M87.1, Osteonecrosis due to drugs; R78.1, Finding of opiate drug in blood; R78.2, Finding of cocaine in blood; R78.3, Finding of hallucinogen in blood; R78.4, Finding of other drugs of addictive potential in blood; R78.5, Finding of psychotropic drug in blood; X40-X44, Accidental poisoning by and exposure to drugs, medicaments and biological substances; X60-X64, Intentional self-poisoning (suicide) by and exposure to drugs, medicaments and biological substances; X85, Assault (homicide) by drugs, medicaments and biological substances; and Y10-Y14, Poisoning by and exposure

to drugs, medicaments and biological substances, undetermined intent. Drug-induced causes exclude accidents, homicides, and other causes indirectly related to drug use. Also excluded are newborn deaths associated with mother's drug use.

### **Codes for alcohol-induced deaths**

The list of codes included in alcohol-induced causes was expanded in the 2003 data year to be more comprehensive. Causes of death attributable to alcohol-induced mortality include ICD-10 codes E24.4, Alcohol-induced pseudo-Cushing's syndrome; F10, Mental and behavioral disorders due to alcohol use; G31.2, Degeneration of nervous system due to alcohol; G62.1, Alcoholic polyneuropathy; G72.1, Alcoholic myopathy; I42.6, Alcoholic cardiomyopathy; K29.2, Alcoholic gastritis; K70, Alcoholic liver disease; K86.0, Alcohol-induced chronic pancreatitis; R78.0, Finding of alcohol in blood; X45, Accidental poisoning by and exposure to alcohol; X65, Intentional self-poisoning by and exposure to alcohol; and Y15, Poisoning by and exposure to alcohol, undetermined intent. Alcohol-induced causes exclude accidents, homicides, and other causes indirectly related to alcohol use. This category also excludes newborn deaths associated with maternal alcohol use.

### **Marital status**

Age-specific and age-adjusted death rates by marital status are shown in table 25 by sex. Mortality data by marital status is generally of high quality. A study of death certificate data using the 1986 National Mortality Followback Survey showed a high level of consistency in reporting marital status (57). Age-adjusted death rates by marital status were computed based on the age-specific rates and the standard population for ages 25 years and over. While age-specific death rates by marital status are shown for the age group 15-24 years, they are not included in the computation of the age-adjusted rate because of their high variability, particularly for the widowed population. Also, the age groups 75-84 and 85 years and over are combined due to high variability in death rates in the 85 year and over age group, particularly for the never married population.

## Educational attainment

Beginning in 2003, some registration areas adopted the new standard death certificate, which includes a revised educational attainment item. This replaces the previous item which focused on highest grade of school completed. Neither the new nor old item captured vocational training. The item was changed to be consistent with the Census data, to improve the ability to identify specific degrees, to improve the ability to identify persons who had completed 12 years of education but did not hold either a GED or high school diploma, and to replace the old item which was inappropriately and inaccurately used to infer degree status. According to testing by the Census Bureau, the new item identifies about 2 percent more individuals with less than a high school diploma or equivalent, 13 percent fewer individuals with a high school diploma, and 8 percent more individuals with at least some college (67). In 2005, the following 17 states used the preferred question: California, Connecticut, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New York, Oklahoma, South Carolina, South Dakota, Utah, Washington, and Wyoming. The District of Columbia implemented the revised certificate in March of 2005 so the old education item was used for part of the year and the revised item was used for part of the year.

Since most states have not yet adopted the preferred question, table 26 is still shown using the old education item. However, [Table II](#) shows a comparison of the percent distribution of deaths by measures of educational attainment in use in 2002 and 2005 for 16 states. The District of Columbia is not included in [Table II](#) because they did not use the new item for the entire year. Also excluded is South Dakota because they first began reporting education in 2004 and, therefore, have no comparison data for 2002.

Table 26 is based on data from 31 states that continue to use the unrevised educational attainment item, and whose data were approximately 80 percent or more complete on a place-of-occurrence basis. Data for Georgia and Rhode Island were excluded because the educational attainment item was not on their certificates. Data for California, Connecticut, District of Columbia, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New York, Oklahoma, South Carolina, South Dakota, Utah, Washington, and Wyoming were also excluded because they used the revised educational attainment item for all or part of 2005,



thus their data would not be comparable to data based on the unrevised item.

Age-specific and age-adjusted death rates by educational attainment are shown in table 26. Age-adjusted death rates by educational attainment were computed based on the age-specific rates and the standard population for ages 25-64 years. Data for age groups 65 years and over are not shown because reporting quality is poorer at older than younger ages (68).

Rates by educational attainment in table 26 are affected by differences in measurement of education for the numerator which is based on number of years of education completed as reported on the 1989 revision of the death certificate and the denominator which is based on highest degree completed as reported on the 2000 Census and the Current Population Surveys (67).

### **Injury at work**

Information on deaths attributed to injuries at work is derived from a separate item on the death certificate that asks the medical certifier whether the death resulted from an injury sustained at work. The item is on the death certificate of all states. Number of deaths, age-specific death rates, and age-adjusted death rates for injury at work are shown in tables 27 and 28. Deaths, crude death rates, and age-adjusted death rates for injury at work are shown for ages 15 years and over. Age-adjusted death rates for injury at work were computed using age-specific death rates and the U.S. standard population based on year 2000 standard for ages 15 years and over. See section on “Computing rates.”

### **Infant mortality**

Infant mortality rates are the most commonly-used index for measuring the risk of dying during the first year of life. The rates presented in this report are calculated by dividing the number of infant deaths in a calendar year by the number of live births registered for the same period and are presented as rates per 1,000 or per 100,000 live births. For final birth figures used in the denominator for infant mortality rates, see *Births: Final Data for 2005* (69). In contrast to infant mortality rates based on live births, infant death rates are based

on the estimated population under 1 year of age. Infant death rates that appear in tabulations of age-specific death rates in this report are calculated by dividing the number of infant deaths by the July 1, 2005 population estimate of persons under 1 year of age, based on 2000 Census populations. These rates are presented as rates per 100,000 population in this age group. Because of differences in the denominators, infant death rates may differ from infant mortality rates.

Another data source is available for infant mortality. The linked file of live births and infant deaths differs from the infant mortality data presented in this report in the following ways: the linked file includes only events in which both the birth and the death occur in the United States and the linked file includes late filed births. During the processing of the linked file, there is an additional opportunity to exclude infant records because of duplicate records or those with additional information that raise questions about their age. Therefore, although the differences are normally miniscule, infant mortality rates based on the linked file tend to be somewhat smaller than those based on data from the general mortality file as presented in this report. The linked file uses the mother's self-reported race from the child's birth certificate (35,36). Because the mother's self-report is of better quality than infant's race from the death certificate and because the numerator and denominator are referring to the same individual's race, the linked file is the preferred source for infant mortality by race.

## **Maternal mortality**

Maternal mortality rates are computed on the basis of the number of live births. The maternal mortality rate indicates the likelihood of a pregnant woman dying of maternal causes. They are calculated by dividing the number of maternal deaths in a calendar year by the number of live births registered for the same period and are presented as rates per 100,000 live births. The number of live births used in the denominator is an approximation of the population of pregnant women who are at risk of a maternal death.

"Maternal deaths" are defined by the World Health Organization as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from

any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes" (9). Included in these deaths are ICD-10 codes A34, O00-O95, and O98-O99.

If a state death certificate includes a separate question regarding pregnancy status, a positive response to the question is interpreted as if "pregnant" was reported in Part II of the cause-of-death section of the death certificate. If a specified length of time is not provided by the medical certifier, it is assumed that the pregnancy terminated 42 days or less prior to death. Further, if only indirect maternal causes of death (i.e., a previously existing disease or a disease that developed during pregnancy which was not due to direct obstetric causes but was aggravated by physiologic effects of pregnancy) are reported in Part I and pregnancy is reported in either Part I or Part II, the death is classified as a maternal death.

An evaluation study for the 1995-97 period found that 35% more maternal deaths were identified through surveillance efforts than solely by using the death certificate. A number of explanations accounted for the under-ascertainment including lack of information reported in the cause-of-death section, use of fewer sources, and some differences in identification (70). This differential conceivably is decreasing because of changes in the coding of indirect maternal causes under ICD-10 that accounted for a nearly 13% increase in maternal deaths in ICD-10 compared to ICD-9 and the increasing use of a pregnancy status checkbox on death certificates.

The 2003 revision of the U.S. Standard Certificate of Death introduced a standard question format with categories to take advantage of additional codes available in ICD-10 for deaths with a connection to pregnancy, childbirth, and the puerperium. As states revise their certificates, most are expected to introduce the standard item or replace pre-existing questions with the standard item, so that there will be wider adoption of a pregnancy status item across the country and greater standardization of the particular item used. As of 2005, 31 states and the District of Columbia (the District of Columbia added the question mid-year) have a separate question related to pregnancy status of female decedents around the time of their death and two states have a prompt encouraging certifiers to report recent pregnancies on the death certificate. However, there are at least 6 different questions used in the 31 states reflecting the mix of states using the 2003 standard format and states

with pre-existing questions.

The number of maternal deaths has increased each year since 2003 as a result of direct and indirect effects of inclusion of a pregnancy status item on the 2003 version of the U.S. Standard Certificate of Death (71). For states that already had a separate question, additional guidance was provided in 2003 in identifying maternal deaths thus resulting in more deaths being identified. For states that adopt the standard item, additional information is available to use in identifying maternal deaths.

### **Quality of reporting and processing cause of death**

One index of the quality of reporting causes of death is the proportion of death certificates coded to Chapter XVIII; Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (ICD-10 codes R00-R99). Although deaths occur for which the underlying causes are impossible to determine, this proportion indicates the care and consideration given to the cause-of-death statement by the medical certifier. This proportion also may be used as a rough measure of the specificity of the medical diagnoses made by the certifier in various areas. The percent of all reported deaths in the United States assigned to Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, in 2005 was 1.31, higher than the percent in 2002, 2003, and 2004 (1.23, 1.28 and 1.26, respectively) but slightly lower than in 2000 and 2001 (1.33 and 1.34 percent, respectively). From 1990 through 1999, the percent of deaths from this cause for all ages combined generally was fairly stable, between 1.08 and 1.18 percent.

Rules for coding a cause(s) of death may sometimes require modification when evidence suggests that such modifications will improve the quality of cause-of-death data. These changes, however, may affect comparability of data between years for select causes of death.

The large increase in Other acute ischemic heart diseases (ICD-10 code I24) in 2005 is largely due to a coding error that was corrected for 2005. Previously, the condition *Acute coronary syndrome* was erroneously assigned to Atherosclerotic heart disease (ICD-10 code I25.1) rather than being assigned to Other acute ischemic heart diseases.

Decreases in deaths classified as due to Cerebrovascular diseases (ICD-10 codes I60-I69) partly reflect actions that the Mortality Reference Group, a WHO advisory body on mortality classification issues, recommended to eliminate conflicting coding instructions in the ICD. The WHO accepted the group's recommendation; the revised rule is effective for the 2005 data year. This change will standardize coding practices internationally, but in doing so, the assignment of some deaths shifted from Cerebrovascular diseases to Multi-infarct dementia (ICD-10 code F01.1) in U.S. data. The Updating and Revision Committee (URC), a WHO advisory group on updates to ICD-10, maintains the cumulative and annual lists of approved updates to the classification ([72](#)).

The large increase in Chronic glomerulonephritis, nephritis and nephropathy not specified as acute or chronic, and renal sclerosis unspecified (ICD-10 codes N02-N03,N05-N07,N26) is largely due to a coding error that was corrected in 2005.

The increase in Necrotizing enterocolitis of newborn (ICD-10 code P77) among infants for 2005 is largely due to a coding rule change (specifically, ICD-10 code P60 can be due to ICD-10 codes P77-P78). The result of the rule change is Necrotizing enterocolitis of newborn is selected as the underlying cause more often than was previously the case.

### **Rare causes of death**

Selected causes of death considered to be of public health concern are routinely confirmed by the states according to agreed upon procedures between the state vital statistics programs and the National Center for Health Statistics. These causes, termed “Infrequent and rare causes of death,” are listed in the NCHS instruction manuals Parts 2a, 11, and 20 ([45,73,74](#)).

For data year 2005, complete confirmation of deaths from infrequent and rare causes was not provided by the following states: Alabama, California, Connecticut, Florida, Illinois, Indiana, Kentucky, Louisiana, Maryland, Michigan, Missouri, Montana, Nevada, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, Texas, Utah, Virginia, Washington, and West Virginia.

## Population bases for computing rates

Populations used for computing death rates and life tables shown in this report represent the population residing in the United States, enumerated as of April 1 for census years and estimated as of July 1 for all other years. Population estimates used to compute death rates for the United States for 2005 are shown by race for 10-year age groups in [Table III](#) and are available by single years of age on the mortality Web site at <http://www.cdc.gov/nchs/datawh/statab/unpubd/mortabs.htm> (75).

Population estimates in [Table IV](#) for Mexicans, Puerto Ricans, Cubans, and Other Hispanics, and population estimates by marital status in [Table V](#), are based on the Current Population Survey adjusted to resident population control totals for the United States (76) and, as such, are subject to sampling variation (see “Random variation”). The control totals used are 2000-based population estimates for the United States for July 1, 2005 (75).

Population estimates by educational attainment, shown in [Table VI](#), are also based on the Current Population Survey adjusted to resident population control totals (76), and are also subject to sampling variation (see “Random variation”). The control totals used are 2000-based population estimates for 31 states for July 1, 2005 (75).

Population estimates for each state, shown in [Table VII](#), were estimated from state-level postcensal population estimates based on the 2000 census, estimated as of July 1, 2005 (75). Population estimates for Puerto Rico, Virgin Islands, Guam, American Samoa, and Northern Marianas, also shown in [Table VII](#), are based on the 2000 census, estimated as of July 1, 2005 (77). Population estimates for each state and territory are not subject to sampling variation because the sources used in demographic analysis are complete counts.

Death rates, shown in this report, for 1991-2005 are based on populations that are consistent with the 2000 census levels (75-83). These estimates were produced under a collaborative arrangement with the U.S. Census Bureau and are based on the 2000 census counts by age, race, and sex, modified to be consistent with U.S. Office of Management and Budget racial categories as of 1977 and historical categories for death data (11). The

modification procedures are described in detail elsewhere (13,14).

## Computing rates

Except for infant and maternal mortality rates, rates are on an annual basis per 100,000 estimated population residing in the specified area. Infant and maternal mortality rates are per 1,000 or per 100,000 live births. Comparisons made in the text among rates, unless otherwise specified, are statistically significant at the 0.05 level of significance. Lack of comment in the text about any two rates does not mean that the difference was tested and found not to be significant at this level.

Age-adjusted rates ( $R'$ ) are used to compare relative mortality risks among groups and over time. However, they should be viewed as relative indexes rather than as actual measures of mortality risk. They were computed by the direct method, that is, by applying age-specific death rates ( $R_i$ ) to the U.S. standard population age distribution (Table VIII)

$$R' = \sum_i \frac{P_{si}}{P_s} R_i$$

where  $P_{si}$  is the standard population for age group  $i$  and  $P_s$  is the total U.S. standard population (all ages combined).

Beginning with the 1999 data year, a new population standard was adopted by NCHS for use in age-adjusting death rates. Based on the projected year 2000 population of the United States, the new standard replaces the 1940 standard population that had been used for over 50 years. The new population standard affects levels of mortality and to some extent trends and group comparisons. Of particular note are the effects on race mortality comparisons. For detailed discussion see *Age Standardization of Death Rates: Implementation of the Year 2000 Standard* (84). Beginning with 2003 data, the traditional standard million population along with corresponding standard weights to six decimal places were replaced by the projected year 2000 population age distribution (see Table VIII). The effect of the change is negligible and does not significantly affect comparability with age-adjusted rates calculated using the previous method.

All age-adjusted rates shown in this report are based on the year 2000 standard population. The year 2000

standard population used for computing age-adjusted rates and standard errors, excluding those by marital status, education, injury at work, and the U.S. territories, is shown in [Table VIII](#).

Age-adjusted rates by marital status were computed by applying the age-specific death rates to the U.S. standard population for ages 25 years and over. Although age-specific death rates by marital status are shown for the age group 15-24 years, they are not included in the calculation of age-adjusted rates because of their high variability, particularly for the widowed population. Also, the age groups 75-84 and 85 years and over are combined because of high variability in death rates in the 85 years and over age group, particularly for the never married population. The year 2000 standard population used for computing age-adjusted rates and standard errors by marital status is shown in [Table IX](#).

Age-adjusted rates by educational attainment were computed by applying the age-specific death rates to the U.S. standard population for ages 25-64 years. Data for age groups 65 years and over are not shown because reporting quality is poorer for older than for younger ages ([68](#)). The year 2000 standard population used for computing age-adjusted rates and standard errors by education is shown in [Table X](#).

Age-adjusted rates for injury at work were computed by applying the age-specific death rates to the U.S. standard population for ages 15 years and over. The year 2000 standard population used for computing age-adjusted rates and standard errors for injury at work is shown in [Table XI](#).

Age-adjusted rates for Puerto Rico, Virgin Islands, Guam, American Samoa, and Northern Marianas were computed by applying the age-specific death rates to the U.S. standard population. Age groups for 75 years and over were combined because population counts were unavailable by age group for ages over 75 years. The year 2000 standard population used for computing age-adjusted rates and standard errors for the territories is shown in [Table XII](#).

Using the same standard population, death rates for the total population and for each race-sex group were adjusted separately. The age-adjusted rates were based on 10-year age groups. It is important not to compare age-adjusted death rates with crude rates.

Death rates for the Hispanic population are based only on events to persons reported as Hispanic. Rates for



non-Hispanic white persons are based on the sum of all events to white decedents reported as non-Hispanic and white decedents with origin not stated. Hispanic origin is not imputed if it is not reported.

## Random variation

The mortality data presented in this report, with the exception of data for 1972, are not subject to sampling error. In 1972 mortality data were based on a 50-percent sample of deaths because of resource constraints. Mortality data, even based on complete counts, may be affected by random variation. That is, the number of deaths that actually occurred may be considered as one of a large series of possible results that could have arisen under the same circumstances (85,86). When the number of deaths is small (perhaps fewer than 100), random variation tends to be relatively large. Therefore, considerable caution must be observed in interpreting statistics based on small numbers of deaths.

*Measuring random variability*—To quantify the random variation associated with mortality statistics, one must make an assumption regarding the appropriate underlying distribution. Deaths, as infrequent events, can be viewed as deriving from a Poisson probability distribution. The Poisson distribution is simple conceptually and computationally, and provides reasonable, conservative variance estimates for mortality statistics when the probability of dying is relatively low (85). Using the properties of the Poisson distribution, the standard error (SE) associated with the number of deaths ( $D$ ) is

$$1. \quad SE(D) = \sqrt{\text{var}(D)} = \sqrt{D}$$

where  $\text{var}(D)$  denotes the variance of  $D$ .

The standard error associated with crude and age-specific death rates ( $R$ ) assumes that the population denominator ( $P$ ) is a constant and is

$$2. \quad SE(R) = \sqrt{\text{var}\left(\frac{D}{P}\right)} = \sqrt{\frac{1}{P^2} \text{var}(D)} = \sqrt{\frac{D}{P^2}} = \frac{R}{\sqrt{D}}$$

The coefficient of variation or relative standard error (RSE) is a useful measure of relative variation. The RSE is calculated by dividing the statistic (e.g., number of deaths, death rate) into its standard error and multiplying by 100. For the number of deaths

$$RSE(D) = 100 \frac{SE(D)}{D} = 100 \frac{\sqrt{D}}{D} = 100 \sqrt{\frac{1}{D}}$$

For crude and age-specific death rates

$$RSE(R) = 100 \frac{SE(R)}{R} = 100 \frac{R / \sqrt{D}}{R} = 100 \sqrt{\frac{1}{D}}$$

Thus,

$$3. \quad RSE(D) = RSE(R) = 100 \sqrt{\frac{1}{D}}$$

The standard error of the age-adjusted death rate ( $R'$ ) is

$$4. \quad SE(R') = \sqrt{\sum_i \left( \frac{P_{si}}{P_s} \right)^2 \text{var}(R_i)} = \sqrt{\sum_i \left\{ \left( \frac{P_{si}}{P_s} \right)^2 \left( \frac{R_i^2}{D_i} \right) \right\}}$$

where

$R_i$  = age-specific rate for the  $i$ th age group

$P_{si}$  = age-specific standard population for the  $i$ th age group from the U.S. standard population age distribution (see [Table VIII](#) and age-adjusted death rate under “Definition of terms”)

$P_s$  = total U.S. standard population (all ages combined)

$D_i$  = number of deaths for the  $i$ th age group

The RSE for the age-adjusted rate,  $RSE(R')$ , can easily be calculated by dividing  $SE(R')$  from formula 4 by the age-adjusted death rate,  $R'$ , and multiplying by 100.

$$RSE(R') = 100 \frac{SE(R')}{R'}$$

For tables showing infant and maternal mortality rates based on live births ( $B$ ) in the denominator, calculation of the standard error assumes random variability in both the numerator and denominator. The standard error for the infant mortality rate ( $IMR$ ) is

$$5. \quad SE(IMR) = \sqrt{\frac{\text{var}(D) + IMR \cdot \text{var}(B)}{E(B)^2}} = \sqrt{\frac{D}{B^2} + \frac{D^2}{B^3}}$$

where the number of births,  $B$ , is also assumed to be distributed according to a Poisson distribution and  $E(B)$  is the expectation of  $B$ .

The RSE for the IMR is

$$6. \quad RSE(IMR) = 100 \frac{SE(IMR)}{IMR} = 100 \sqrt{\frac{1}{D} + \frac{1}{B}}$$

For maternal mortality rates, formulas 5 and 6 may be used substituting the maternal mortality rate for the IMR.

Formulas 1-6 may be used for all tables presented in this report except for death rates and age-adjusted death rates shown in tables 5, 25, and 26 which are calculated using population figures that are subject to sampling error (see the following subsection).

*Tables 5, 25, and 26*—Death rates for Mexicans, Puerto Ricans, Cubans, and Other Hispanics in table 5, rates by marital status in table 25 and rates by educational attainment in table 26 are based on population estimates derived from the U.S. Bureau of the Census' Current Population Survey (CPS) for 2005 and adjusted to resident population control totals. As a result, the rates are subject to sampling variability in the denominator as well as random variability in the numerator.

For crude and age-specific death rates ( $R$ ) the standard error is calculated as

$$7. \quad SE(R) = R \sqrt{\frac{1}{D} + 0.67 \left( a + \frac{b}{P} \right)}$$

For age-adjusted death rates ( $R'$ )

$$8. \quad SE(R') = \sqrt{\sum_i \left\{ \left( \frac{P_{si}}{P_s} \right)^2 R_i^2 \left[ \frac{1}{D_i} + 0.67 \left( a + \frac{b}{P_i} \right) \right] \right\}}$$

where  $a$  and  $b$  in formulas 7 and 8 represent parameters presented in [Table XIII](#), which are derived from the CPS data for 2005 and 2006 and vary depending on the subgroup of interest ([87,88](#)).

*Suppression of unreliable rates*—Beginning with 1989 data, an asterisk is shown in place of a crude or age-specific death rate based on fewer than 20 deaths, the equivalent of an RSE of 23 percent or more. The limit of 20 deaths is a convenient, if somewhat arbitrary, benchmark, below which rates are considered to be too statistically unreliable for presentation. For infant and maternal mortality rates, the same criterion (fewer than 20 deaths) is used to determine whether an asterisk is presented in place of the rate. For age-adjusted death rates the suppression criterion is based on the sum of the age-specific deaths; i.e., if the sum of the age-specific deaths is fewer than 20, an asterisk is presented in place of the rate. These procedures are used throughout this report except for death rates shown in tables 5, 25, and 26.

For death rates shown in tables 5, 25, and 26, sampling variability in the population denominator has a substantial impact on the overall variability in the rate. Therefore, the number of deaths in the numerator is not used as the sole suppression factor. RSEs for rates shown in tables 5, 25, and 26 are derived from formulas 7 and 8 by dividing the results of formulas 7 and 8, by the crude/age-specific rate and age-adjusted rate, respectively, and multiplying by 100. Rates are replaced by asterisks if the calculated RSE is 23 percent or more. In some cases, for smaller population subgroups, the estimated sample population from the CPS may be zero, even though deaths are presented for these same subgroups. In these cases, the death rate is incalculable and is automatically replaced with an asterisk.

*Confidence intervals and statistical tests based on 100 deaths or more*—When the number of deaths is large, a normal approximation may be used in the calculation of confidence intervals and statistical tests. How large is to some extent a subjective judgment. In general, for crude and age-specific death rates and for infant and maternal mortality rates, the normal approximation performs quite well when the number of deaths is 100 or greater. For age-adjusted rates, the criterion for use of the normal approximation is somewhat more complicated ([59,84,89](#)). Formula 9 is used to calculate 95-percent confidence limits for the death rate when the normal approximation is appropriate.

$$9. \quad L(R) = R - 1.96(SE(R)) \text{ and } U(R) = R + 1.96(SE(R))$$

where  $L(R)$  and  $U(R)$  are the lower and upper limits of the confidence interval, respectively. The resulting 95-percent confidence interval can be interpreted to mean that the chances are 95 in 100 that the “true” death rate falls between  $L(R)$  and  $U(R)$ . For example, suppose that the crude death rate for Malignant neoplasms is 188.7 per 100,000 population based on 559,312 deaths. Lower and upper 95-percent confidence limits using formula 9 are calculated as

$$L(188.7) = 188.7 - 1.96(.25) = 188.2 \text{ and } U(188.7) = 188.7 + 1.96(.25) = 189.2$$

Thus, the chances are 95 in 100 that the true death rate for malignant neoplasms is between 188.2 and 189.2.

Formula 9 can also be used to calculate 95-percent confidence intervals for the number of deaths, age-adjusted death rates, infant mortality rates, and other mortality statistics when the normal approximation is appropriate by replacing  $R$  with  $D$ ,  $R'$ ,  $IMR$ , etc.

When testing the difference between two rates,  $R_1$  and  $R_2$  (each based on 100 or more deaths), the normal approximation may be used to calculate a test statistic,  $z$ , such that

$$10. \quad z = \frac{R_1 - R_2}{\sqrt{SE(R_1)^2 + SE(R_2)^2}}$$

If  $|z| \geq 1.96$  then the difference between the rates is statistically significant at the 0.05-level. If  $|z| < 1.96$  then the difference is not statistically significant. Formula 10 can also be used to perform tests for other mortality statistics when the normal approximation is appropriate (when both statistics being compared meet the normal criteria) by replacing  $R_1$  and  $R_2$  with  $D_1$  and  $D_2$ ,  $R'_1$  and  $R'_2$ , etc. Suppose that the female age-adjusted death rate for Malignant neoplasms of trachea, bronchus, and lung (lung cancer) is 40.9 per 100,000 U.S. standard population in 2004 ( $R_1$ ) and 40.5 per 100,000 U.S. standard population in 2005 ( $R_2$ ). The standard error for each of these figures,  $SE(R_1)$  and  $SE(R_2)$ , is calculated using formula 4. Using formula 10, one can test if the decrease in the age-adjusted rate is statistically significant.

$$z = \frac{40.9 - 40.5}{\sqrt{(0.157)^2 + (0.155)^2}} = 1.81$$

Because  $z=1.81 < 1.96$ , the decrease from 2004 to 2005 in the female age-adjusted death rate for lung cancer is not statistically significant.

*Confidence intervals and statistical tests based on fewer than 100 deaths*—When the number of deaths is not large (fewer than 100), the Poisson distribution cannot be approximated by the normal distribution. The normal distribution is a symmetric distribution with a range from  $-\infty$  to  $+\infty$ . As a result, confidence intervals based on the normal distribution also have this range. The number of deaths or the death rate, however, cannot be less than zero. When the number of deaths is very small, approximating confidence intervals for deaths and death rates using the normal distribution will sometimes produce lower confidence limits that are negative. The Poisson distribution, in contrast, is an asymmetric distribution with zero as a lower bound. Thus, confidence limits based on this distribution will never be less than zero. A simple method based on the more general family of gamma distributions, of which the Poisson is a member, can be used to approximate confidence intervals for deaths and death rates when the number of deaths is small (84,89). For more information regarding how the gamma method is derived, see *Derivation of the gamma method* at the end of this section.

Calculations using the gamma method can be made using commonly available spreadsheet programs or statistical software (e.g., Excel, SAS) that include an inverse gamma function. In Excel, the function “`gammainv(probability, alpha, beta)`” returns values associated with the inverse gamma function for a given probability between 0 and 1. For 95 percent confidence limits, the probability associated with the lower limit is  $.05/2=.025$  and the probability associated with the upper limit is  $1-(.05/2)=.975$ . Alpha and beta are parameters associated with the gamma distribution. For the number of deaths and crude and age-specific death rates,  $\alpha=D$  (the number of deaths) and  $\beta=1$ . In Excel, the following formulas can be used to calculate lower and upper 95 percent confidence limits for the number of deaths and crude and age-specific death rates

$$L(D)=\text{GAMMAINV}(.025, D, 1) \quad \text{and} \quad U(D)=\text{GAMMAINV}(.975, D+1, 1)$$

Confidence limits for the death rate are then calculated by dividing  $L(D)$  and  $U(D)$  by the population ( $P$ ) at risk

of dying (see formula 17).

Alternatively, 95 percent confidence limits can be estimated using the lower and upper confidence limit factors shown in [Table XV](#). For the number of deaths,  $D$ , and the death rate,  $R$ ,

$$11. L(D) = L \times D \quad \text{and} \quad U(D) = U \times D$$

$$12. L(R) = L \times R \quad \text{and} \quad U(R) = U \times R$$

where  $L$  and  $U$  in formulas 11 and 12 are the lower and upper confidence limit factors which correspond to the appropriate number of deaths,  $D$ , in [Table XIV](#). For example, suppose that the death rate for American Indian females aged 1-4 is 45.6 per 100,000 and based on 38 deaths. Applying formula 12, values for  $L$  and  $U$  from [Table XIV](#) for 38 deaths are multiplied by the death rate, 45.6 such that

$$L(R) = L(45.6) = 0.707660 \times 45.6 = 32.3 \quad \text{and} \quad U(R) = U(45.6) = 1.372578 \times 45.6 = 62.6$$

These confidence limits indicate that the chances are 95 out of 100 that the actual death rate for American Indian females aged 1-4 is between 32.3 and 62.6 per 100,000.

Although the calculations are similar, confidence intervals based on small numbers for age-adjusted death rates, infant and maternal mortality rates, and rates that are subject to sampling variability in the denominator are somewhat more complicated (59,84). Refer to the most recent version of the Mortality Technical Appendix for more details (<http://www.cdc.gov/nchs/dataawh/statab/pubd/ta.htm>).

When comparing the difference between two rates,  $R_1$  and  $R_2$  where one or both of the rates are based on fewer than 100 deaths, a comparison of 95 percent confidence intervals may be used as a statistical test. If the 95 percent confidence intervals do not overlap, then the difference can be said to be statistically significant at the 0.05-level. A simple rule of thumb is: if  $R_1 > R_2$  then test if  $L(R_1) > U(R_2)$  or if  $R_2 > R_1$  then test if  $L(R_2) > U(R_1)$ . Positive tests denote statistical significance at the 0.05-level. For example, suppose that American Indian females aged 1-4 have a death rate ( $R_1$ ) of 45.6 based on 38 deaths and Asian and Pacific Islander (API) females aged 1-4 have a death rate ( $R_2$ ) of 17.5 per 100,000 based on 67 deaths. The 95 percent confidence limits for  $R_1$  and  $R_2$  calculated using formula 12 would be

$$L(R_1) = L(45.6) = 0.707660 \times 45.6 = 32.3 \quad \text{and} \quad U(R_1) = U(45.6) = 1.372578 \times 45.6 = 62.6$$

$$L(R_2) = L(17.5) = 0.774986 \times 17.5 = 13.6 \quad \text{and} \quad U(R_2) = U(17.5) = 1.269965 \times 17.5 = 22.2$$

Because  $R_1 > R_2$  and  $L(R_1) > U(R_2)$ , it can be concluded that the difference between the death rates for American Indian females 1-4 and API females of the same age is statistically significant at the .05-level. That is, taking into account random variability, API females 1-4 have a death rate that is significantly lower than that for American Indian females of the same age.

This test may also be used to perform tests for other statistics when the normal approximation is not appropriate for one or both of the statistics being compared by replacing  $R_1$  and  $R_2$  with  $D_1$  and  $D_2$ ,  $R'_1$  and  $R'_2$ , etc.

Users of the method of comparing confidence intervals should be aware that this method is a conservative test for statistical significance. That is, the difference between two rates may, in fact, be statistically significant even though confidence intervals for the two rates overlap (90). Thus, caution should be observed when interpreting a non-significant difference between two rates, especially when the lower and upper limits being compared overlap only slightly.

*Derivation of the gamma method*—For a random variable  $X$  that follows a gamma distribution  $\Gamma(y, z)$ , where  $y$  and  $z$  are the parameters that determine the shape of the distribution (91):  $E(X) = yz$  and  $Var(X) = yz^2$ . For the number of deaths,  $D$ ,  $E(D)=D$  and  $Var(D)=D$ . It follows that  $y=D$  and  $z=1$  and thus,

$$13. \quad D \sim \Gamma(D, 1)$$

From equation 13, it is clear that the shape of the distribution of deaths depends only on the number of deaths.

For the death rate,  $R$ ,  $E(R)=R$  and  $Var(R) = \frac{D}{P^2}$ . It follows, in this case, that  $y=D$  and  $z = P^{-1}$  and thus,

$$14. \quad R \sim \Gamma(D, P^{-1}).$$

A useful property of the gamma distribution is that for  $X \sim \Gamma(y, z)$ , one can divide  $X$  by  $z$  such that  $\frac{X}{z} \sim \Gamma(y, 1)$ .

This converts the gamma distribution into a simplified, standard form dependent only on parameter  $y$ .

Expressing equation 14 in its simplified form gives



$$15. \quad \frac{R}{P^{-1}} = D \sim \Gamma(D,1)$$

From equation 15, it is clear that the shape of the distribution of the death rate is also dependent solely on the number of deaths.

Using the results of equations 13 and 15, one can use the inverse gamma distribution to calculate upper and lower confidence limits. Lower and upper 100(1- $\alpha$ ) percent confidence limits for the number of deaths,  $L(D)$  and  $U(D)$ , are estimated as

$$16. \quad L(D) = \Gamma^{-1}_{(D,1)}(\alpha/2) \quad \text{and} \quad U(D) = \Gamma^{-1}_{(D+1,1)}(1-\alpha/2)$$

where  $\Gamma^{-1}$  represents the inverse of the gamma distribution and  $D+1$  in the formula for  $U(D)$  reflects a continuity correction made necessary by the fact that  $D$  is a discrete random variable and the gamma distribution is a continuous distribution. For a 95 percent confidence interval,  $\alpha=.05$ . For the death rate, it can be shown that

$$17. \quad L(R) = \frac{L(D)}{P} \quad \text{and} \quad U(R) = \frac{U(D)}{P}$$

For more detail regarding the derivation of the gamma method and its application to age-adjusted death rates and other mortality statistics, see references (59,84,89).

### **Availability of mortality data**

Mortality data are available in publications, unpublished tables, and electronic products as described on the mortality web site at the following address: <http://www.cdc.gov/nchs/deaths.htm>. More detailed analysis than provided in this report is possible by using the Mortality public-use data set issued each data year. Since 1968, the data set is available through NCHS in ASCII format. Data are also available in the *Vital Statistics of the United States*, *Mortality*, and *Vital and Health Statistics*, Series 20 reports, and the *National Vital Statistics Reports* through NCHS.

## Definitions of terms

*Infant deaths* —Deaths of infants aged under 1 year.

*Neonatal deaths*—Deaths of infants aged 0–27 days.

*Postneonatal deaths*—Deaths of infants aged 28 days–1 year.

*Crude death rate*—Total deaths per 100,000 population for a specified period. The crude death rate represents the average chance of dying during a specified period for persons in the entire population.

*Age-specific death rate*—Deaths per 100,000 population in a specified age group, such as 1–4 years or 5–9 years for a specified period.

*Age-adjusted death rate*—The death rate used to make comparisons of relative mortality risks across groups and over time. This rate should be viewed as a construct or an index rather than as direct or actual measure of mortality risk. Statistically, it is a weighted average of the age-specific death rates, where the weights represent the fixed population proportions by age.

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